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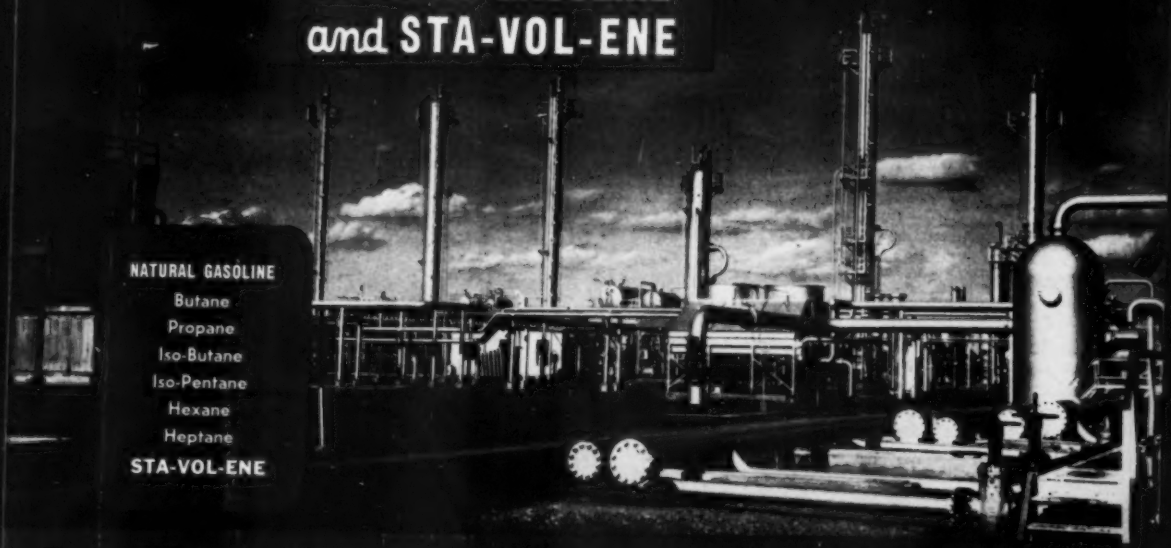

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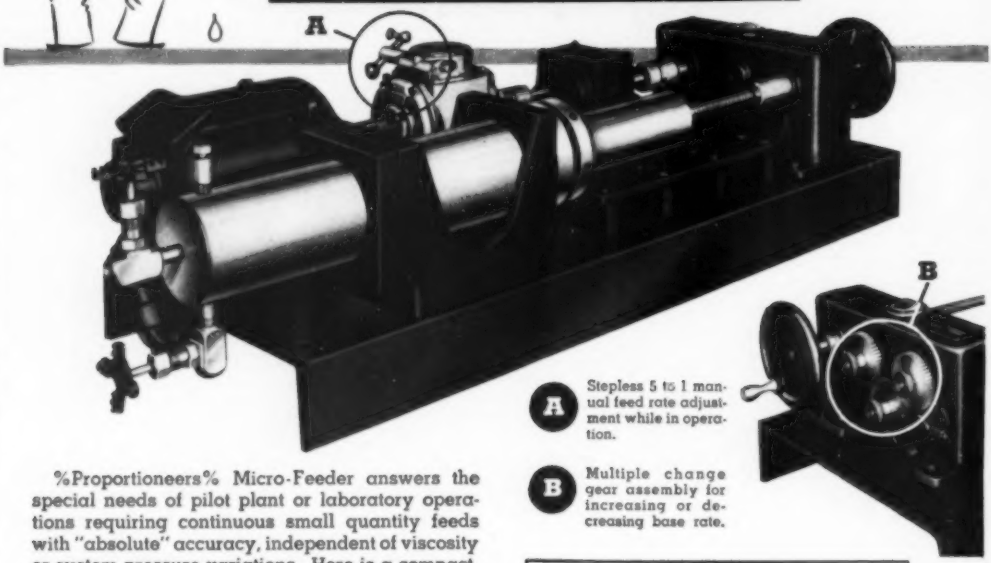

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Single copies 50 cents (except special issues) for U. S. and Canada; $1 for all other countries. Subscription rates—U. S. and Canada $2 a year; Latin America $8 a year; overseas $10 a year. PETROLEUM REFINER, published on the 10th of every month, entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act March 3, 1879. Advertising rates on application. Copyright 1952 by The Gulf Publishing Company.

Petroleum Refiner is indexed by Industrial Arts Index and by Engineering Index, Inc.

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No. 5

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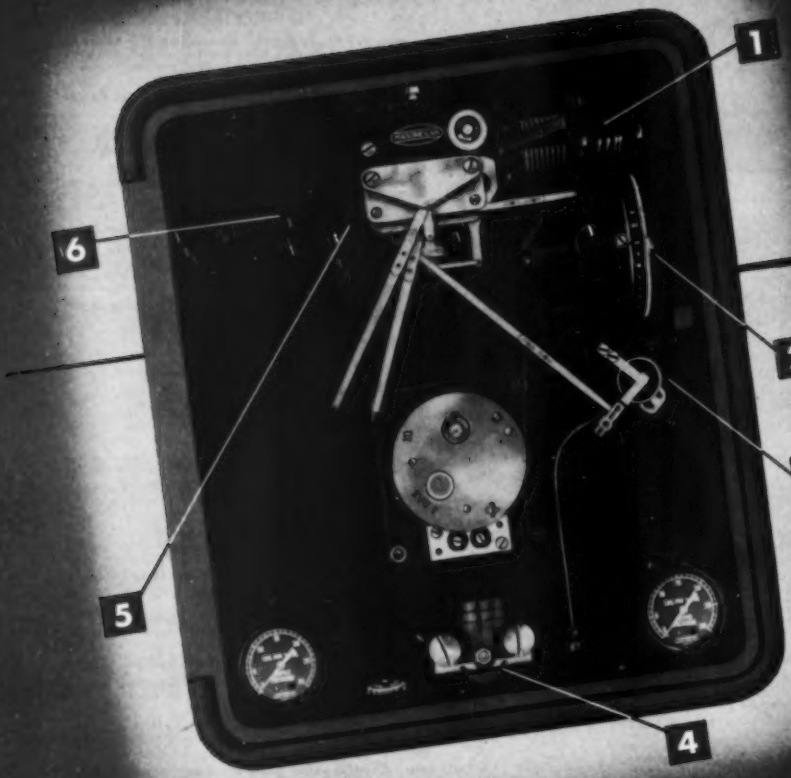

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What tube steel gives you the best life/cost ratio? Ask the experts!

This month's report is on: **2% CR.-MO.**

Has intermediate corrosion resistance in combination with good creep strength and fair resistance to oxidation. For use at temperatures up to 1200° F. in cracking coils, reforming units, heat exchangers, vapor line and hot oil piping, and return-bend forgings for oil heaters.

23 TIMKEN® STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	16-13-3*
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	25-20*
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-12*
Silmo	Sicromo 3	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
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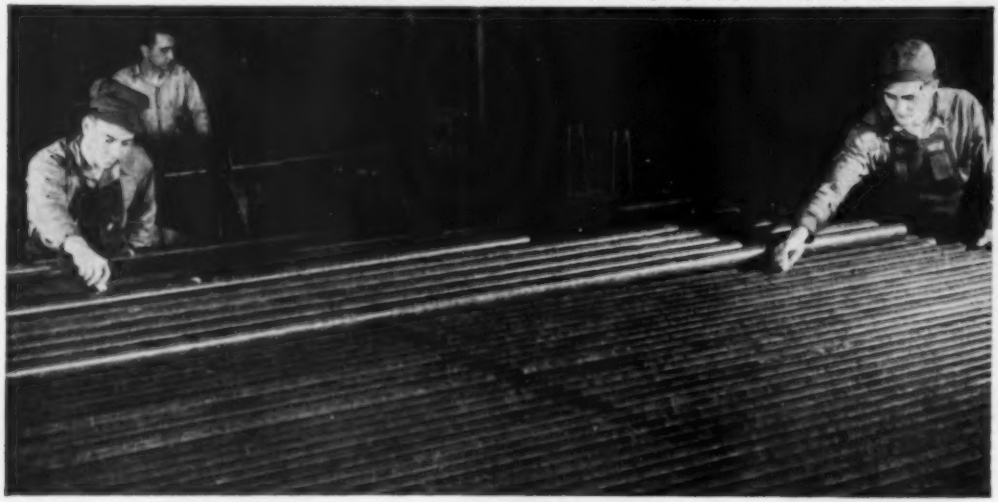
*Not available as seamless tubing at the present time.

MAYBE you can find several high temperature tube steels that will solve your particular set of heat, pressure, corrosion and oxidation problems. But there's only *one* steel that will give you maximum tube life per dollar—the best life/cost ratio.

To find that one steel, go to the metallurgists of The Timken Roller Bearing Company. They're recognized authorities on high temperature steels. Backed by 20 years' experience and research and with 23 different analyses at their disposal, they'll help you choose the one best steel for your application. And you'll be assured of uniform quality in every tube because of the Timken Company's rigid quality control from melt shop through final inspection.

Our "RSQ"—Research, Supply, Quality—can solve your tube problems. *Ask the experts!* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

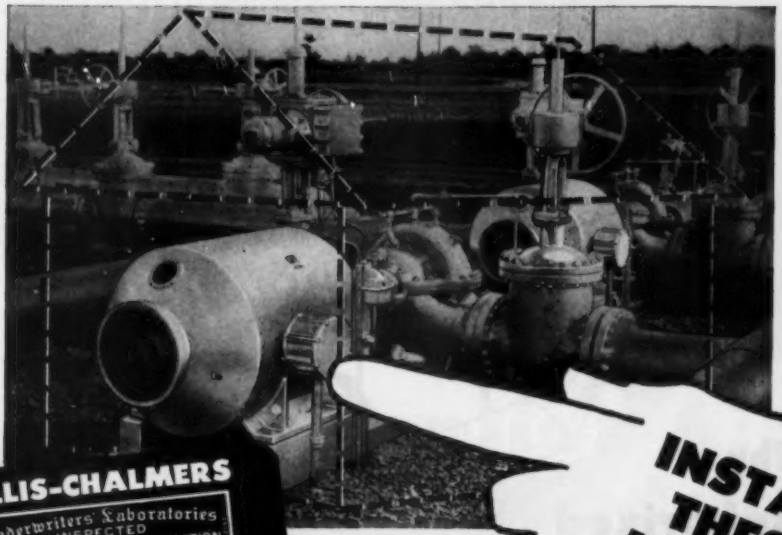
Photo below shows final tube inspection—last of hundreds of rigid tests that help account for the uniform quality of Timken high temperature steels.



YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

No building to buy!



INSTALL THESE MOTORS OUTDOORS

YOU CAN ELIMINATE costly building on many different kinds of installations by using Allis-Chalmers Tube-type, Explosion-proof Motors and installing them outdoors. The motors shown here operate outdoors all year round at a midwestern pipe line booster station. Rain, snow, dirt, the weather's worst conditions, do not affect their dependable operation. And the same kind of savings can be made in hundreds of other applications in the field, on pipe lines and in the refinery.

Self-Cleaning Feature Saves Maintenance

The cooling system in this unique motor is practically self-cleaning. Cooling air is blown through straight, smooth tubes at sufficient velocity to clean out ordinary dirt, even after long shutdowns. There are no corners or pockets to trap dirt or moisture. If sticky dirt clings, a ramrod will clean the tubes in seconds without stopping the motor.

On any type of duty, indoors or out, Allis-Chalmers Tube-type, Explosion-proof Motors reduce maintenance by keeping themselves clean. Get full details from your Allis-Chalmers Authorized Distributor or District Office. Or write Allis-Chalmers, Milwaukee 1, Wis., asking for bulletin 51B7149.

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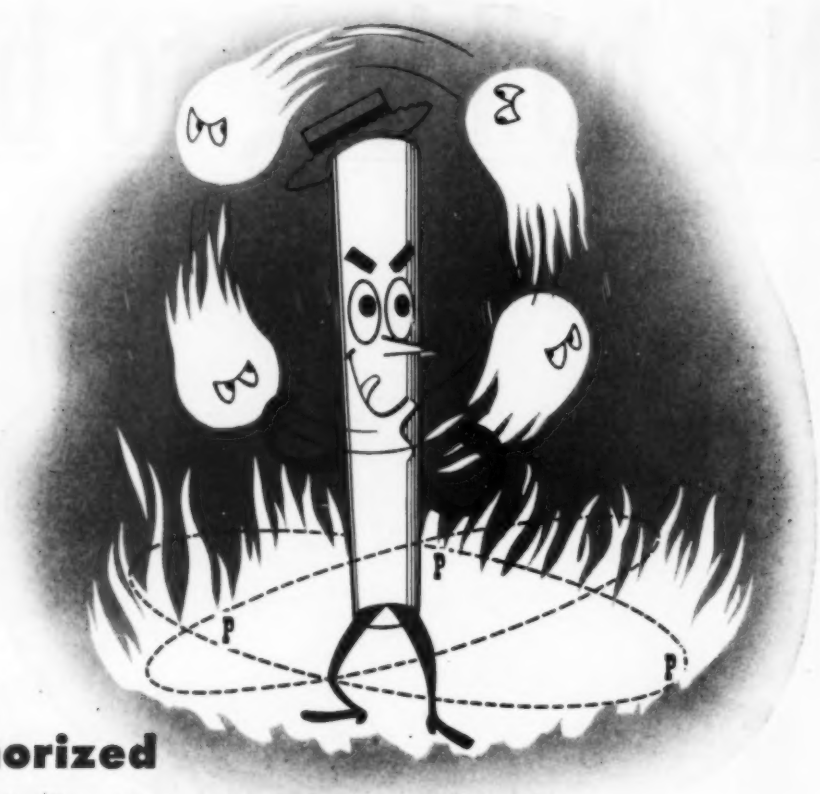

Why Phosphorized Admiralty Heat Exchanger Tubes?

Excellent Performance at Relatively High Operating Temperatures

In order to assure *uniform* chemical composition and inherent *soundness*, Scovill produces Phosphorized Admiralty tubes by its continuous billet-casting process which consistently maintains the optimum amount of phosphorus. Adding as little as 0.02% phosphorus to Admiralty also gives maximum resistance to dezincification while retaining all the other desirable properties of this alloy.

Scovill's 40-page Condenser Tube Booklet is available to users who request it on their business letterhead. Scovill Manufacturing Company, 14 Mill Street, Waterbury 20, Connecticut.

Only Scovill Phosphorized Admiralty Has All These Advantages . . .

- Uniformity and soundness resulting from Scovill continuous-casting techniques
- Relative immunity to dezincification
- High resistance to sulfides and other active sulphur compounds
- Satisfactory resistance to weak mineral acids and acid mine waters
- Good resistance to velocities under 7 fps
- Excellent performance at relatively high operating temperatures
- Superior performance in fresh, salt or brackish waters

SCOVILL HEAT EXCHANGER TUBES

"You can't buy better brass"

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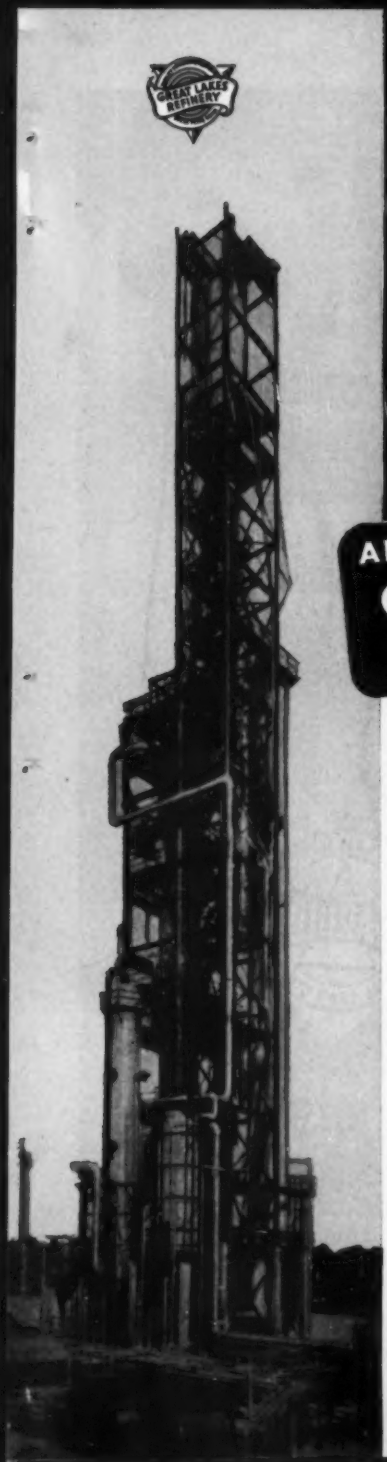

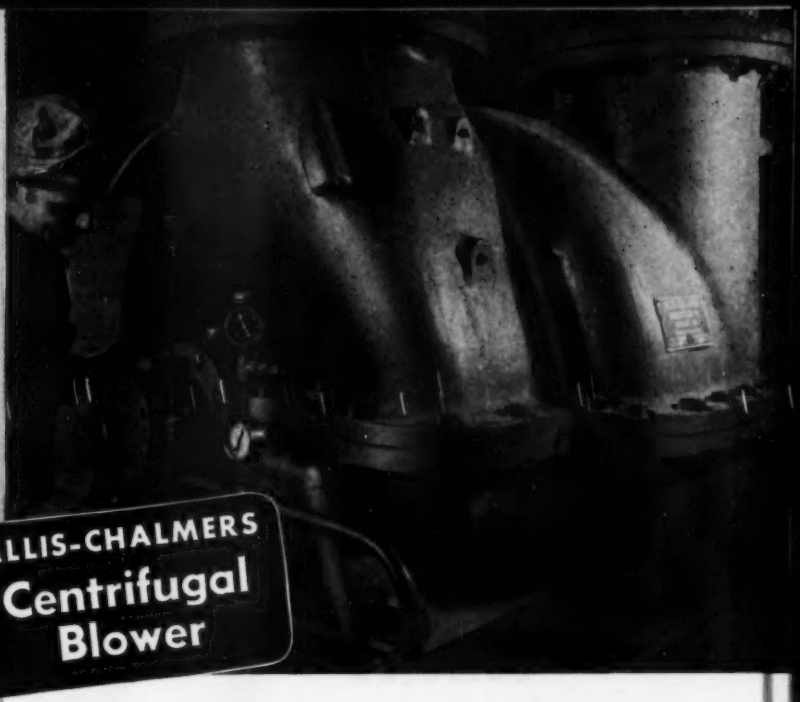

ALLIS-CHALMERS
Centrifugal
Blower

Supplies Air to New Houdriflow

ALL THE AIR NEEDED for catalyst regeneration *and* transportation in this new Houdriflow Catalytic Cracking unit is supplied by *one* Allis-Chalmers multi-stage centrifugal blower.

Put "on stream" in 1951, the unit is one of the many of its type already in operation. It is located in Blue Island, Ill. at the Great Lakes Refinery, a division of the Petco Corporation.

The new method extracts a higher percentage of gasoline from the crude and yet requires less equipment and instrumentation. The catalyst is both aerated and moved by the air from the one Allis-Chalmers multi-stage blower, rated 10,500 cfm at 12 psig. No mechanical means are required.

The blower and cracker operate 24 hrs a day, seven days a week, producing 6,000 bbls of gasoline per day. This particular refinery of the Petco Corporation has a daily capacity of 15,000 bbls and 300,000 bbls storage.

In the trend to more efficient cracking methods, the petroleum industry employs an ever-increasing number of centrifugal blowers. While one multi-stage blower is used in the Houdriflow process for two functions, other new cracking processes employ two single stage centrifugal blowers.

Your refinery expansion program also can benefit from Allis-Chalmers wide experience in building and applying blowing equipment in the petroleum industry. For more information or literature call your nearest A-C office or write Allis-Chalmers, Milwaukee 1, Wis. New Multi-Stage Bulletin 19B6104A is now available. A-35/0

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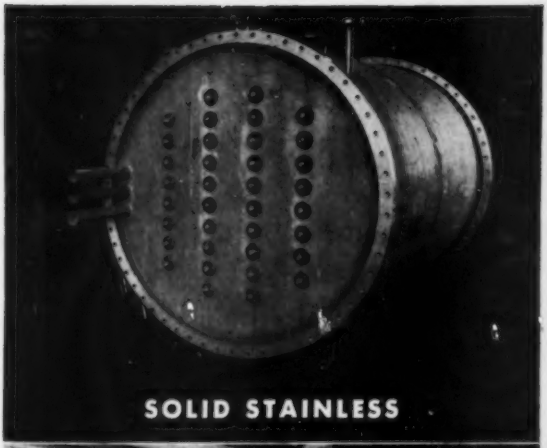

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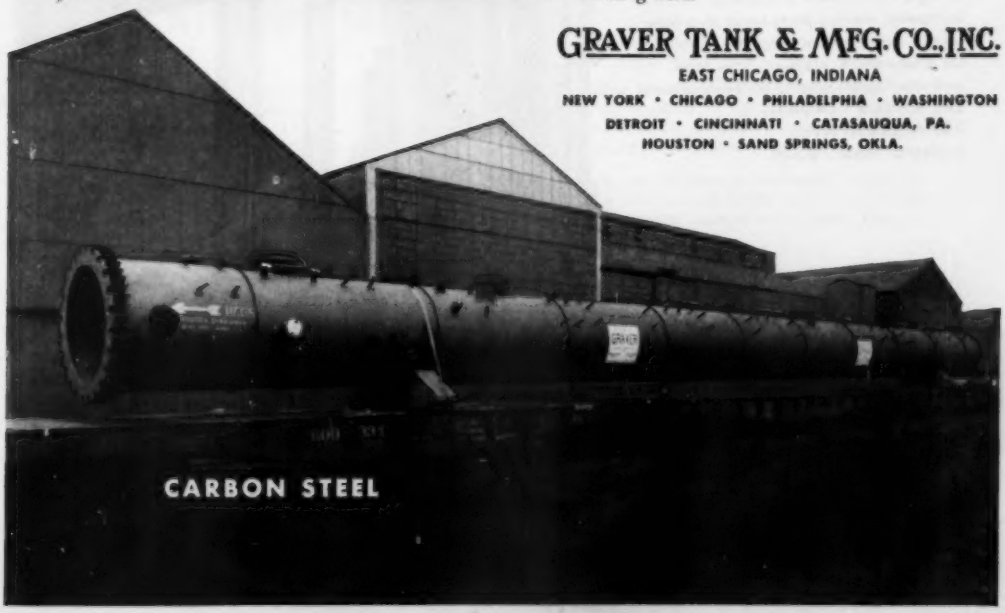


CARBON STEEL

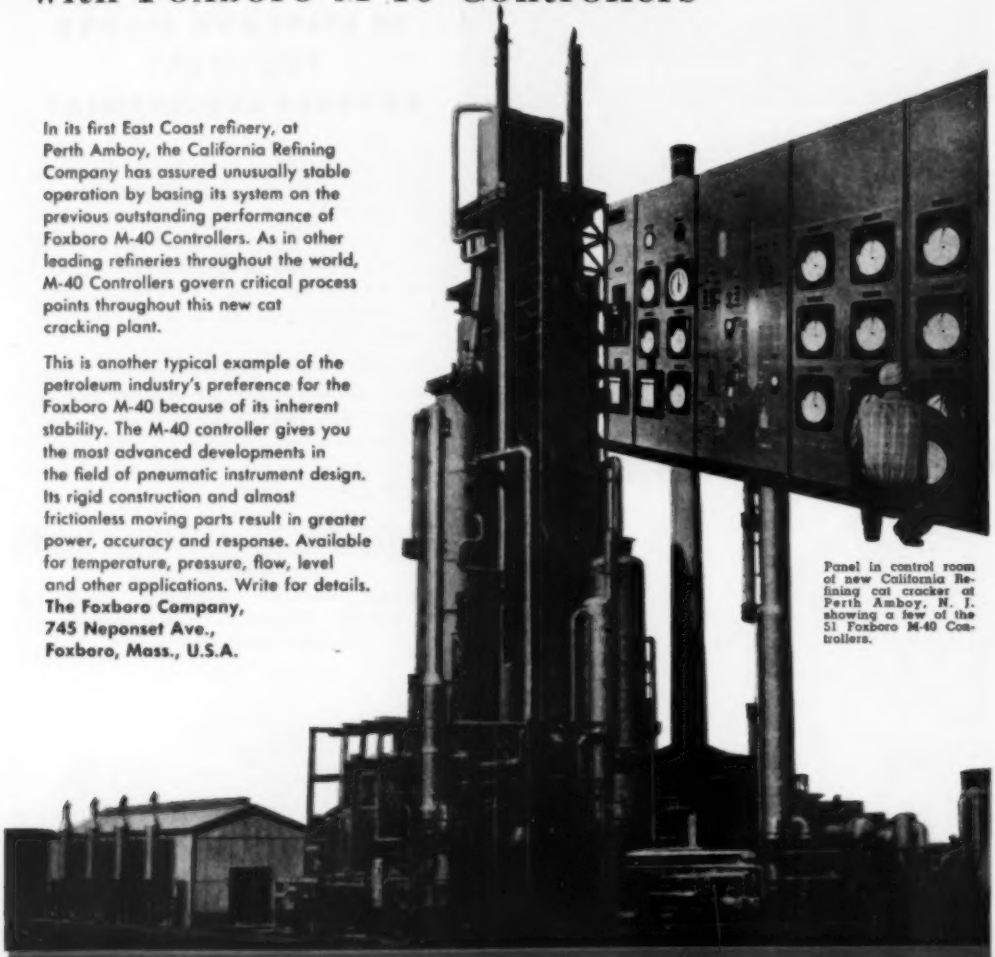
Cal. Refining

"Cashes-in" on past experience with Foxboro M-40 Controllers

In its first East Coast refinery, at Perth Amboy, the California Refining Company has assured unusually stable operation by basing its system on the previous outstanding performance of Foxboro M-40 Controllers. As in other leading refineries throughout the world, M-40 Controllers govern critical process points throughout this new cat cracking plant.

This is another typical example of the petroleum industry's preference for the Foxboro M-40 because of its inherent stability. The M-40 controller gives you the most advanced developments in the field of pneumatic instrument design. Its rigid construction and almost frictionless moving parts result in greater power, accuracy and response. Available for temperature, pressure, flow, level and other applications. Write for details.

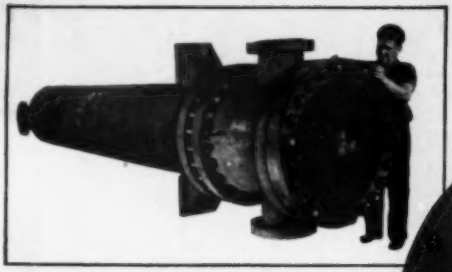
The Foxboro Company,
745 Neponset Ave.,
Foxboro, Mass., U.S.A.



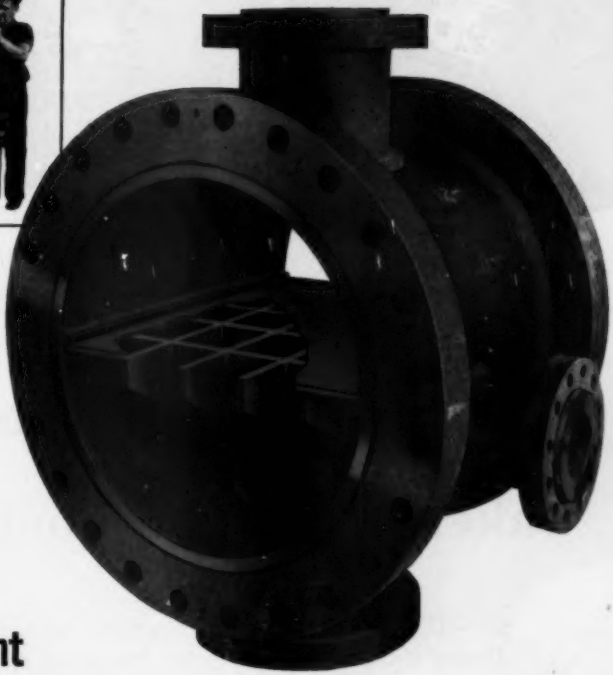
Panel in control room of new California Refining cat cracker at Perth Amboy, N. J. showing a few of the 51 Foxboro M-40 Controllers.

FOXBORO
Reg. U. S. Pat. Off.
CONTROLLERS

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND



High-level reactor exchanger **built for one of the world's largest Ethanol plants, showing copper-lined channel and removable copper pass rib with unusual reinforcement designed to give support against high pressure drop at elevated temperatures.**



How A.O.Smith protected heat transfer equipment from the effects of Phosphoric Acid Corrosion and Hydrogen Diffusion

The problem was solved for Stone & Webster Engineering Corporation of Boston, engineers and designers of the Chemical Project of the British Petroleum Chemicals, Ltd., at Grangemouth, Scotland, with this deoxidized copper-lined, high-level reactor exchanger.

Our metallurgical laboratories ran tests on various materials in collaboration with Stone & Webster Engineering Corporation and Shell Development Company, the process licensor, which aided them in establishing deoxidized copper as the most suitable material for the protective lining.

Our welding laboratories then determined procedures to be used in the shop for welding copper to copper, copper to steel, and silver-soldering copper to steel.

Combining all laboratory assistance with the experience of the A.O. Smith heat transfer and mechanical design groups made production of this unit possible.

A.O.Smith has been retained as consultants on today's most complex heat transfer problems and the facilities employed in solving them are available to you.

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For 111 years "Worthington" has meant *pumps* to industry everywhere.

During this period, Worthington has developed a position of leadership in many related fields. Fourteen major product lines including pumps are manufactured in 21 plants throughout the world.

To those we serve, Worthington is *more than pumps*. That's why the world's leading manufacturer of pumps has changed its name from

WORTHINGTON PUMP AND MACHINERY CORPORATION

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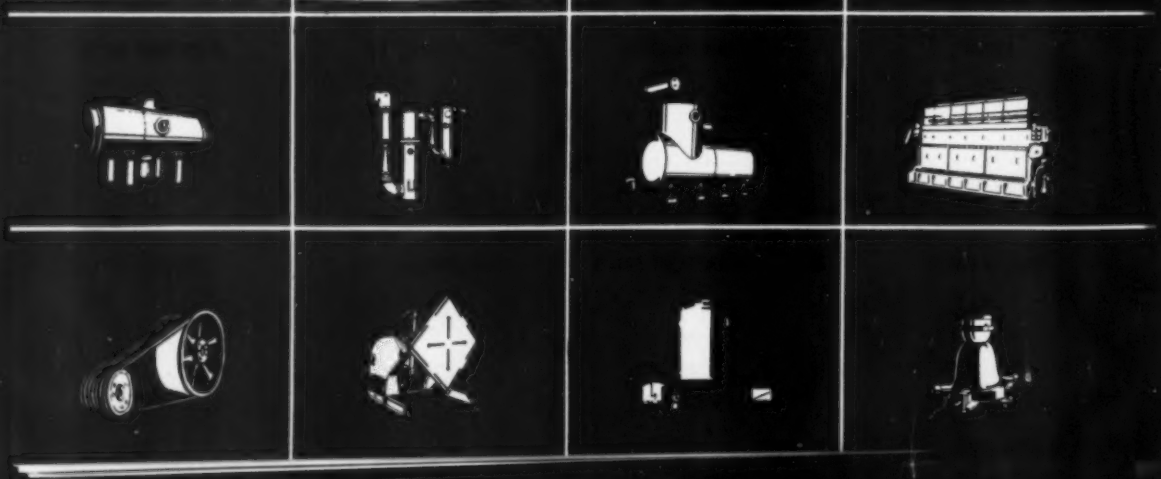
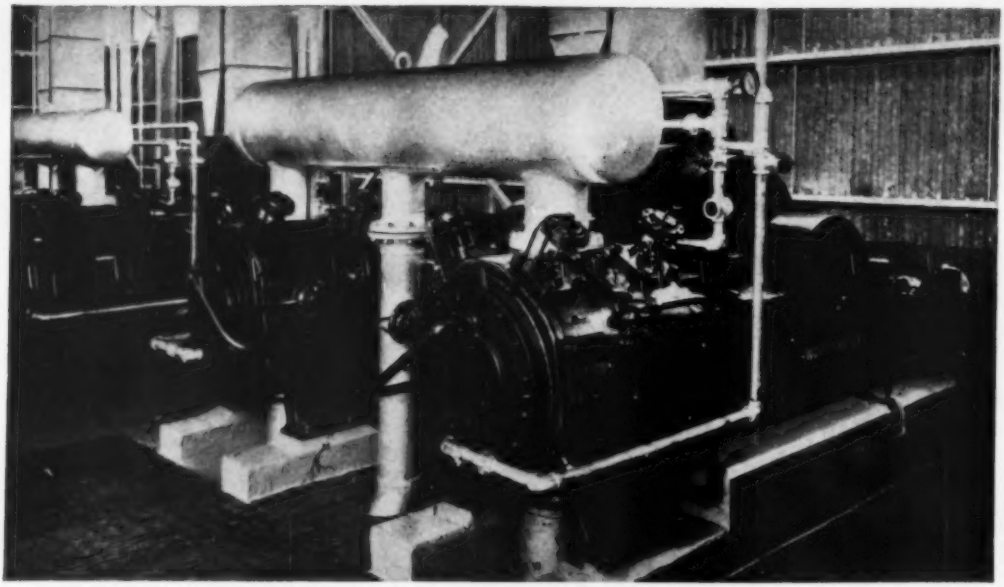


the World



A New Cracking System at Socony-Vacuum ...BUT THE SAME COMPRESSORS

When Socony-Vacuum needed to modernize its catalytic cracking plant in Buffalo, it put in the thermofor process.

To compress hydrocarbons for the process, Socony-Vacuum selected Worthington DC compressors. Why?

Because—the three Worthington compressors on the old Houdry system performed successfully . . . since 1939.

So . . . in addition to these three, Socony-Vacuum now has four more compressors working on the Thermofor unit. One of these four (not shown in the picture) is a 4-cylinder tandem compressor with a unique control system permitting it to operate on either low or high pressure service.

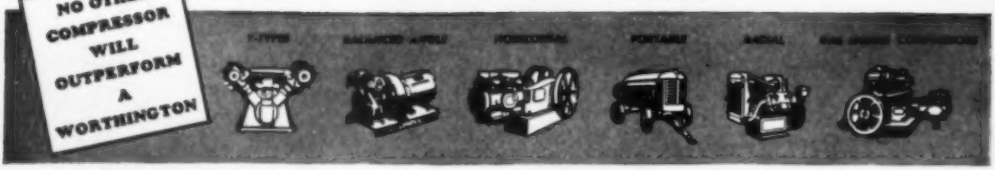
This case illustrates not only the *dependability* of Worthington compressors but also the *adaptability* of the Worthington line to all refinery requirements —all types of gases, all pressures, all capacities. In addition, Worthington provides the broadest line of pumps, engines, refrigeration equipment and other petroleum processing machinery.

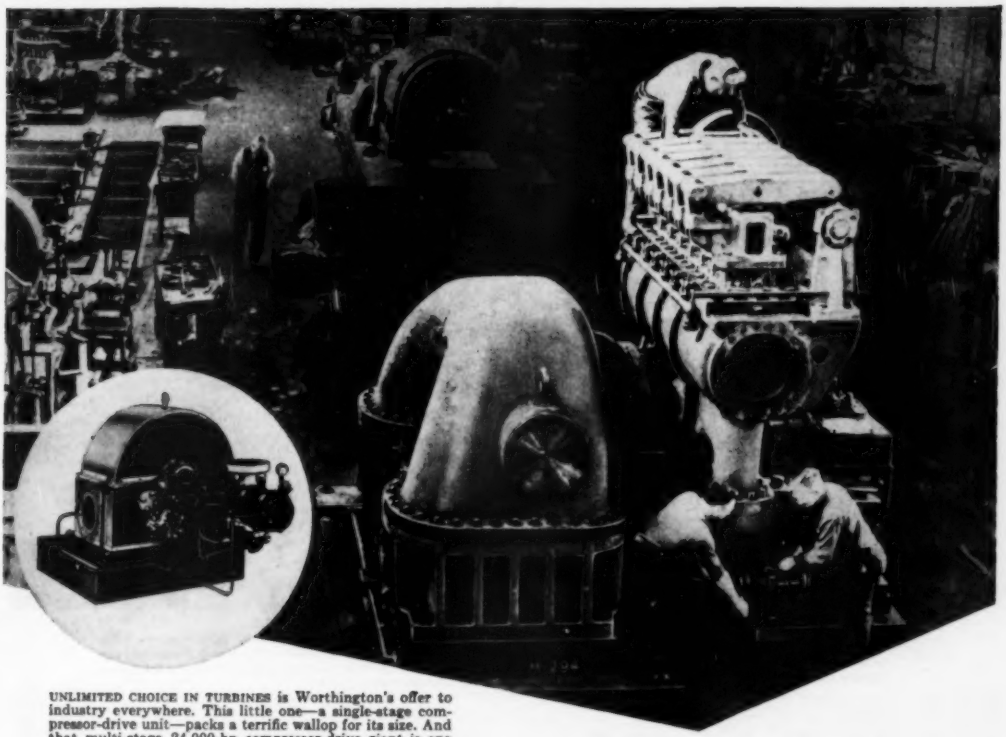
Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Compressor Division, Buffalo, New York.

WORTHINGTON

COMPRESSORS

24K3.4





UNLIMITED CHOICE IN TURBINES is Worthington's offer to industry everywhere. This little one—a single-stage compressor-drive unit—packs a terrific wallop for its size. And that multi-stage 24,000-hp compressor-drive giant is one of the largest ever built for this type of service.

Single-stage midgets to multi-stage giants

Whether your turbine requirements call for the biggest or the smallest—straight condensing . . . straight non-condensing . . . extraction . . . mixed pressure extraction . . . low pressure . . . high back pressure . . . for mechanical or generator drive . . . with governors for constant or variable speed—*Worthington has an answer.*

Each Worthington turbine is designed to make the steam do *more* work, so you save power and money throughout its long life.

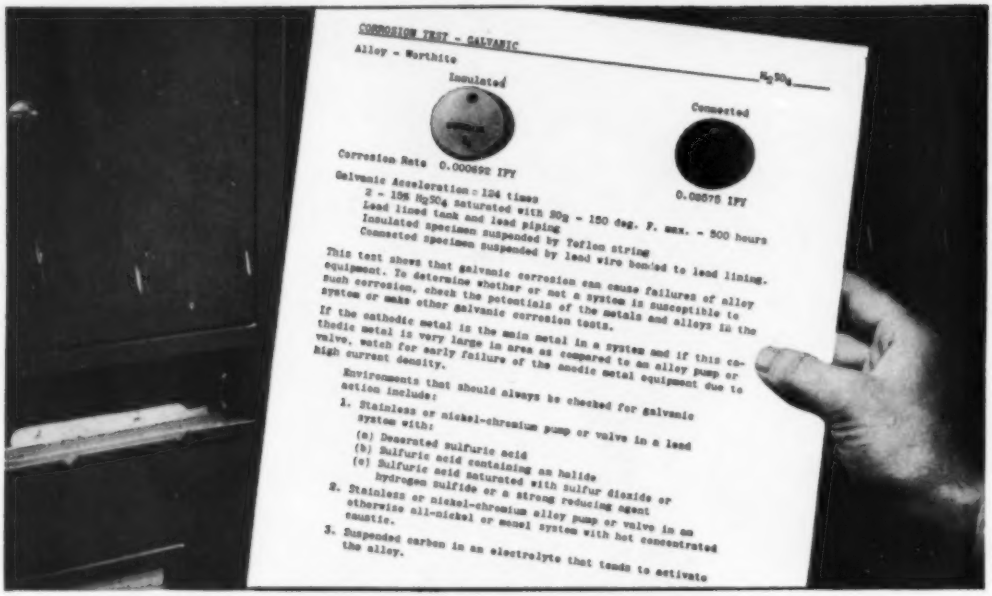
Learn more about Worthington turbines. Get the facts on why *there's more worth in Worthington* by writing to Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Steam Turbine Division, Wellsville, N. Y.

T.2.2

A GREAT TEAM IN STEAM

WORTHINGTON

Steam Turbines


CORROSION TEST - GALVANIC
Alloy - Worthite
H_2SO_4
Insulated
Connected
Corrosion Rate 0.000892 IPY
0.03675 IPY
Galvanic Acceleration = 124 times
2 - 15% H_2SO_4 saturated with SO_2 - 150 deg. F. max. - 500 hours
Lead lined tank and lead piping
Insulated specimen suspended by Teflon string
Connected specimen suspended by lead wire bonded to lead lining.
This test shows that galvanic corrosion can cause failures of alloy equipment. To determine whether or not a system is susceptible to such corrosion, check the potentials of the metals and alloys in the system or make other galvanic corrosion tests.
If the cathodic metal is the main metal in a system and if this cathodic metal is very large in area as compared to an alloy pump or valve, watch for early failure of the anodic metal equipment due to high current density.
Environments that should always be checked for galvanic action include:
1. Stainless or nickel-chromium pump or valve in a lead system with:
(a) Deaerated sulfuric acid
(b) Sulfuric acid containing an halide
(c) Sulfuric acid saturated with sulfur dioxide or hydrogen sulfide or a strong reducing agent
2. Stainless or nickel-chromium alloy pump or valve in an otherwise all-nickel or monel system with hot concentrated caustic.
3. Suspended carbon in an electrolyte that tends to activate the alloy.

A CASE STUDY FROM THE WORTHINGTON FILES. This Worthington test sheet indicates that the galvanic action could be virtually eliminated in this manufacturer's system by *insulation*—that is, a complete separation of the alloy pump from metallic contact with lead surfaces. The recommendation was made to him as a result of a Worthington test made on the solutions his system was pumping.

It Takes More Than A Pump To Solve A Pumping Problem!

Worthington's files are packed with many stories like this one. Each is proof positive that you get a lot more than a Worthite* pump when you buy from Worthington.

It was the age-old problem of chemical pumping, corrosion. But this customer found a way out—a *practical solution* that saved him plenty of expense in extra maintenance and lost production time.

He wrote a letter to Worthington. Could we tell him whether there was anything he could do to slow down or stop this corrosion? He was pumping a 15% solution of sulfuric acid saturated with sulfur dioxide. Maximum temperature of solution was 150° F.

This wasn't a new problem for Worthington corrosion specialists. Experience had shown them that under these conditions galvanic action could be his trouble. They ran the test illustrated above which conclusively proved these assumptions correct.

Result? The customer insulated the system and his troublesome corrosion problem was brought under control.

At Worthington, we welcome the chance to hear about *your* pumping problems—either on a present installation or in the design of a new system. For it is only through such close contact with the industry that we can continue to build the kind of pumps and offer the kind of services that have led pump users the world over to the conclusion that *there's more worth in Worthington.*

Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.

*Reg. U. S. Pat. Off. C.1.6

Types CG and CGL. Sizes ¾" to 10". Capacities to 5000 GPM; heads to 200 ft. Liquid ends of WORTHITE.

Type CF. Sizes 1" to 4". Capacities to 1000 GPM; heads to 130 ft. Standard, all iron and all bronze.

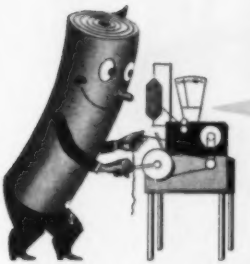
Type CQ. Sizes 1½" to 3". Capacities to 600 GPM; heads to 130 ft. at 1750 RPM. Closed impeller.

Type L. Sizes 3" to 8". Capacities to 2250 GPM; heads to 300 ft. Single stage volute. For general service.

WORTHINGTON

Centrifugal Pumps

The World's Broadest Line Assures You the Right Pump for Every Job



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Gives You Greater Fabric Uniformity

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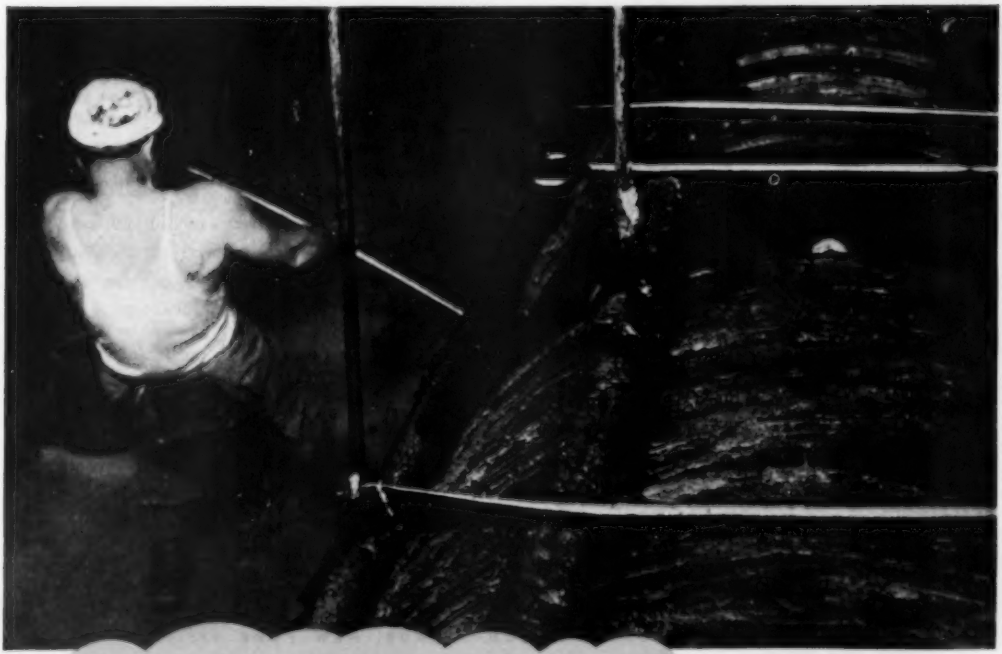

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Selling Agents
40 WORTH ST. NEW YORK

...today's dollar and tomorrow's returns

Here at Lummus we hold a deep respect for our customers' 1952 dollar and 1957 returns. *This* has a meaning all its own to responsible management with capital to commit for petroleum, petroleum chemical and chemical plants.

You'll find these price-and-value factors well taken care of in every project designed, engineered and constructed by Lummus. On each job, *process improvement* is the paramount goal—achieved by applying every technological advancement and modern design. This we won't compromise, no matter how great the demand may be for immediate new production facilities.

What's more, the plants must have the flexibility to answer needs of the future. Engineering ingenuity at Lummus concerns itself with taking every precaution today against a future time when outmoded tools may put you at a competitive disadvantage.

That sums up our interpretation of judicious spending. Over six hundred soundly-designed, profit-producing plants have been built on this steadfast concept. You may wish to bear these facts in mind on *your* next project.

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DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

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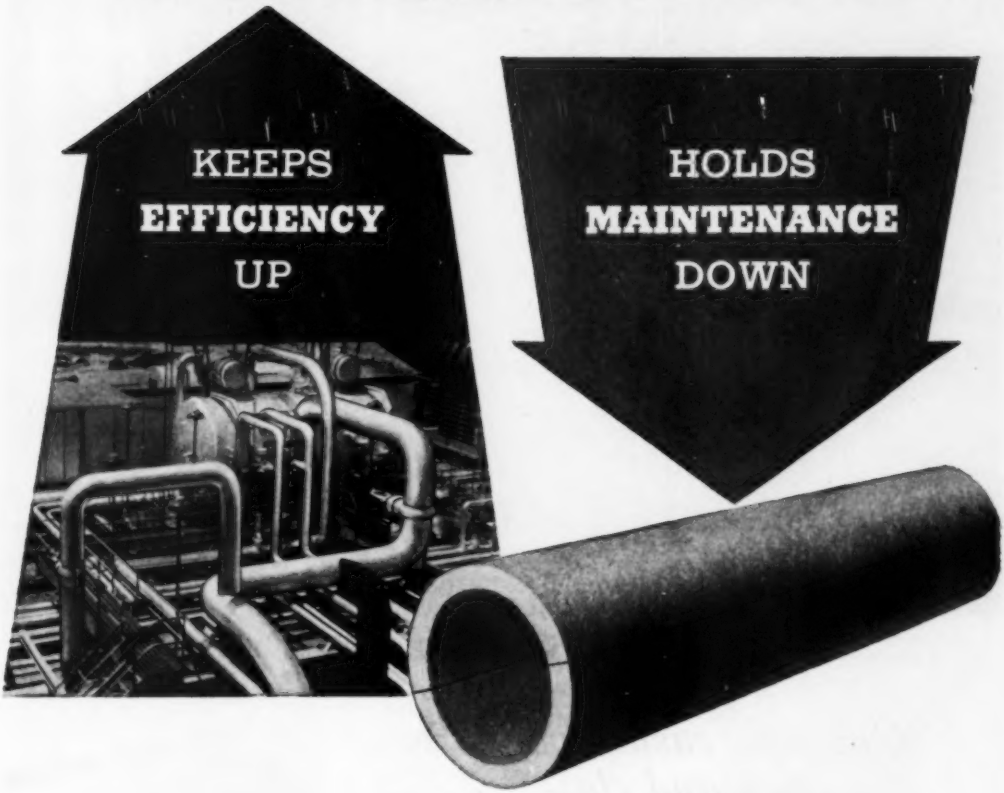


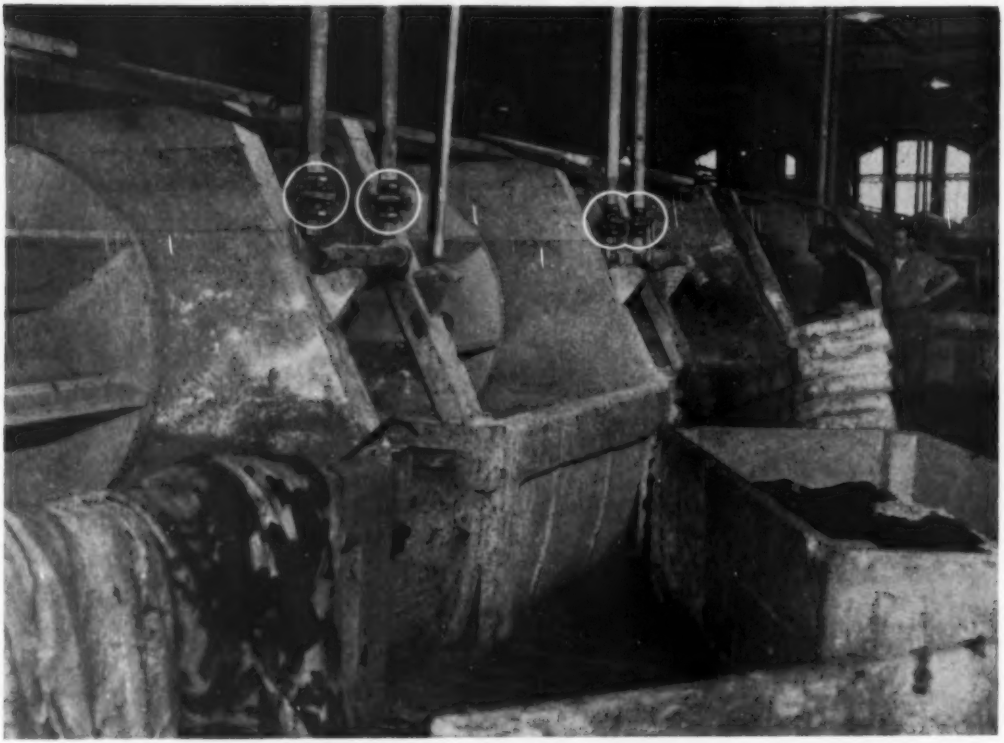
Write for Bulletin No. 76-109, and the name of the Unarco Warehousing Distributor in your area.

Want to reduce heat-loss, surface temperature, and *maintenance costs*—all at the same time? You can, with Unibestos! And you can get stock delivery from your Unarco Distributor in cylinders, half-rounds, or blocks. When temperatures go as high as 1200°F., specify Unibestos No. 1200—and Unibestos No. 750 for up to 750°F., maximum. Or, where temperatures won't run over 600°F., ask for Unarco Amocel—it has many of the same excellent features. Unibestos and Amocel are easy to install, stay put, resist all service hazards.

UNARCO

UNION ASBESTOS & RUBBER COMPANY

DEPT. D-5 • 332 SOUTH MICHIGAN AVENUE • CHICAGO 4, ILLINOIS



IN THE BEAMHOUSE above, Rockwood Ball Valves proved their worth in service. This tannery process removes hair from hides through "liming." Valves must be opened and closed constantly, must resist lime and acid vapors.

"Quickest, easiest valves to open and close,"

REPORTS TANNERY

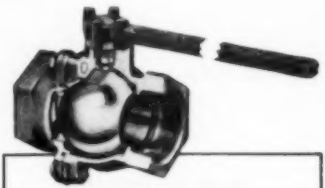
"They're sure built to take it," declares Cornelius Baltas, foreman of the Beamhouse, Creese and Cook Company. "And the Rockwood Ball Valve helped speed production, too. My men found them easy to get at, quick to open, quick to close — a big feature when opening and closing occurs all day long."

In this tannery installation, Rockwood Ball Valves carried water at 200° F to 220° F into lime paddle. Being leakproof, they prevented costly damage to hides from hot water . . . also proved resistant to strong lime and acid vapors that attack metals.

YOU, TOO, CAN BENEFIT

Tough tannery conditions are among many in which the use of Rockwood Ball Valves proves invaluable. Thousands of these valves are providing outstanding service in oil refineries, food, paper, textile, chemical, and rubber plants. Used in lines handling all types of liquids and gases, such as carbon dioxide, nitrogen, paraffin and asphalt base petroleums, alcohol and others. Available in bronze in pipe sizes from ¼" to 2" and in cast steel from 3" to 4". Recommended for 300 psi working pressure. Approved by Underwriters' Laboratories, Inc.

If you are not already using Rockwood Valves, plan now to benefit from them. For further details, write for Bulletin V-4 today. Get complete data including prices and applications.



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- **QUICK OPENING AND CLOSING**
- **NO MAINTENANCE**

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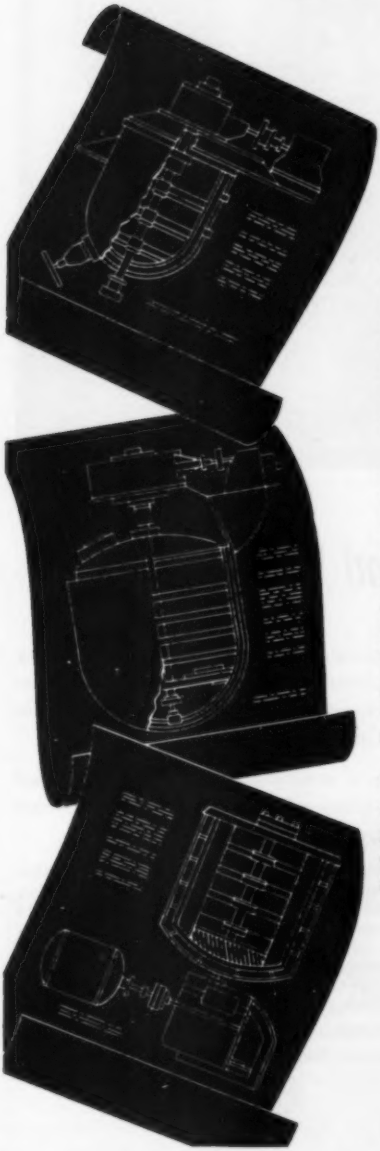
ROCKWOOD BALL VALVES

ROCKWOOD SPRINKLER COMPANY, 102 HARLOW STREET, WORCESTER 5, MASS.

DEPENDABLE

Grease Kettles by STRUTHERS WELLS



Struthers Wells will engineer mixing kettles for greases or other heavy viscous materials—to your most exact specifications and requirements. Kettles can be furnished with agitating drive at top or bottom—open, closed or pressure top—jacketed or unjacketed—in any metal or alloy desired. Advanced design provides proper seals where pressure top is used.

Sweep and paddle arms are pitched to create flow of material throughout kettle, preventing stratifying of mix. Scraper blades insure positive scraping action on about 98% of inside surface of mixer. Bottom bearing is accessible for easy maintenance or replacement. Flush type valve at bottom furnished in sizes from 1" to 8"

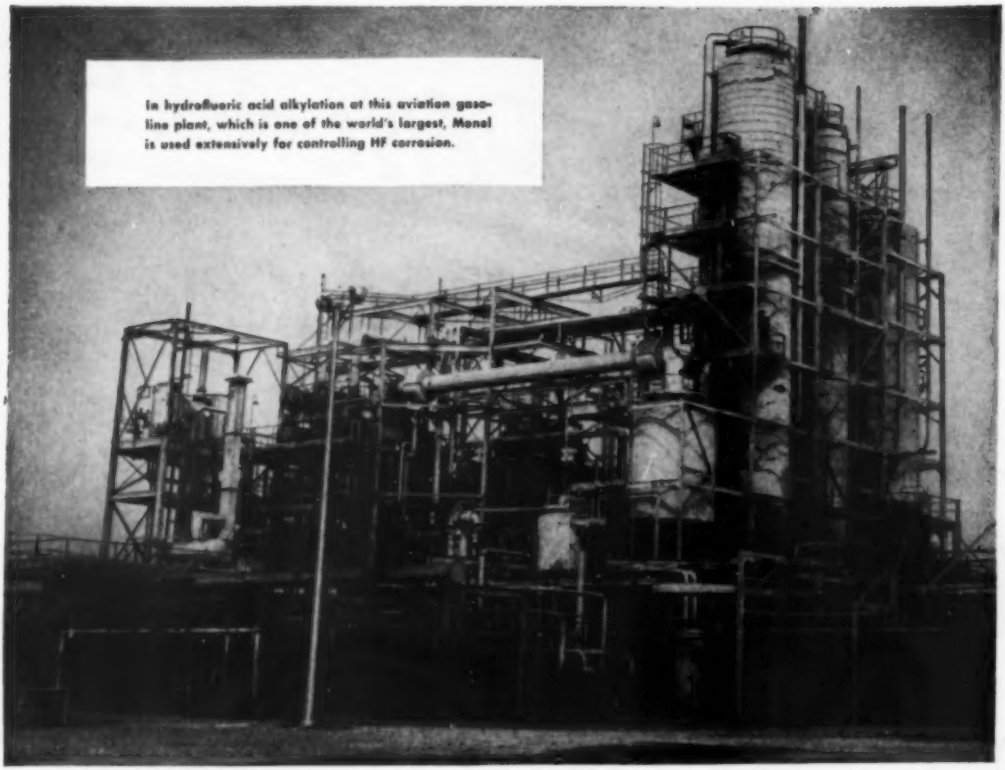
Write for proposal on intricate or standard mixing equipment—engineered for your specific needs.

Struthers Wells

STRUTHERS WELLS CORPORATION

Process Equipment Department • **WARREN, PA.**

Plants at Titusville, Pa. • Warren, Pa. • Offices in Principal Cities



In hydrofluoric acid alkylation at this aviation gasoline plant, which is one of the world's largest, Monel is used extensively for controlling HF corrosion.

MONEL *for handling* HF *and* FLUORINE

Experience has proved that for maximum safety, and corrosion resistance, Monel® is among the most satisfactory materials of construction for handling fluorine and its more active compounds.

Monel is highly resistant to ignition by fluorine. It has been successfully used to handle fluorine at pressures up to 400 pounds per square inch, and has shown economical corrosion resistance at temperatures up to about 900°F.

Not only is Monel highly resistant to attack by fluorine, it also shows good corrosion resistance to anhydrous hydrogen fluoride and to steam-HF mixtures, even at temperatures as high as 1100°F. A proven practical application of these facts has been the established use of Monel in hydrofluoric acid alkylation units in petroleum plants.

In addition to excellent chemical characteristics are Monel's well-known physical properties... high strength ...easy fabrication and welding.

But remember, Monel is on extended delivery now because so much is taken for defense. In order to improve your chances of getting delivery when you need it, it's wise to place your orders — with necessary NPA rating and complete end use information — well in advance of your construction schedule. And if you have a special metal problem, Inco's Technical Service Section will be glad to help you solve it. Write today, giving full details.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N.Y.

INCO
TRADE MARK

MONEL ... for minimum maintenance

Why Ingersoll-Rand

VERTICAL PUMPS

are HIGH in performance

and LOW in installation and maintenance

OPERATION IS BETTER

These rugged, vertical process pumps have repeatedly proved their dependability and unusually high economy in services the world over. The shaft and impeller assembly is in complete radial balance. And positive alignment is maintained by accurate machined fits of all mating sections. The proven design of these units—with each part of the most suitable material for the application—assures *sustained* high efficiency.

INSTALLATION IS EASIER

The in-line arrangement of suction and discharge nozzles permits simple, straight-through piping—without loops or elbows. Piping can be located above or below floor level, as desired. Compact, vertical design conserves space—eliminates the need for large foundations, bedplates and grouting.

MAINTENANCE IS SIMPLIFIED

There is only one stuffing box—easily accessible through openings in the discharge head. Either conventional packing or the I-R Cameron Shaft Seal can be used. There is no thrust bearing to maintain, residual thrust being taken by the motor bearing. And the segmented inner casing assembly is easy to dismantle and assemble for inspection or servicing. Maximum interchangeability of impellers and diffusor sections reduces spare parts inventories.

The inherent advantages of vertical design particularly suit these pumps to many chemical and process services. Your nearest Ingersoll-Rand branch office engineer will be glad to study your next pumping problem with you. Whether the solution indicated calls for a vertical or horizontal unit, you are assured of obtaining the *right* pump for the job when you specify Ingersoll-Rand.

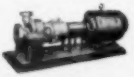
Ingersoll-Rand

CAMERON PUMP DIVISION
11 Broadway, New York 4, N. Y.

508-10-A

THERE'S AN I-R CENTRIFUGAL PUMP FOR EVERY PROCESS NEED

Single-stage, vertically split
Capacities—20 to 550 gpm
Pressures—to 300 psi

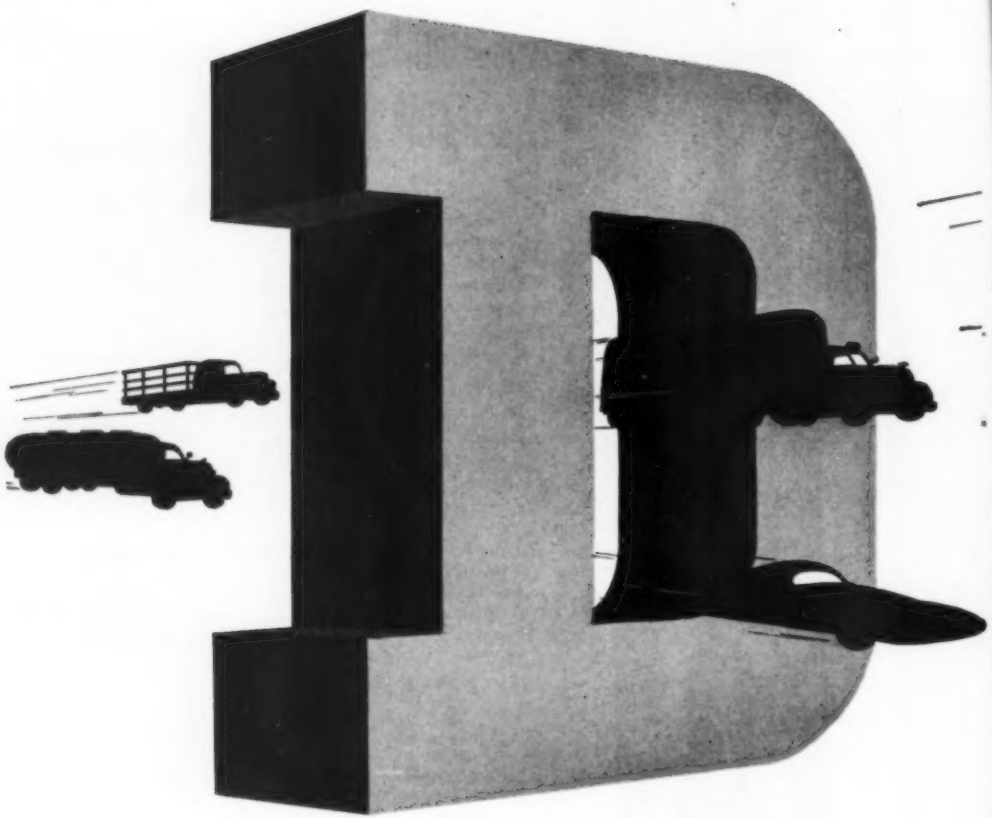


Single- and two-stage, vertically split
Capacities—10 to 3000 gpm
Pressures—to 600 psi

Single- and two-stage, horizontally split
Capacities—20 to 3500 gpm
Pressures—to 500 psi

Multi-stage, with cylindrical "double-case" construction
Capacities—to 2800 gpm
Pressures—to 3000 psi

COMPRESSORS — — AIR TOOLS — ROCK DRILLS — TURBO BLOWERS — CONDENSERS — CENTRIFUGAL PUMPS — DIESEL AND GAS ENGINES



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The operating efficiency of synthetic fluid-type cracking catalysts is important. This operating efficiency can be assured by uniformity of physical characteristics and chemical purity. Davison's production of microspheroidal (M-S*) is tops in uniformity . . . providing all users with a highly efficient synthetic fluid-type cracking catalyst. Your requirements can also be supplied in ground (DA-1*) form. Write for further descriptive information. Experienced Davison Field Service Engineers backed up with complete laboratory testing facilities are part of Davison's service.

*T.M.T.D.C.C.

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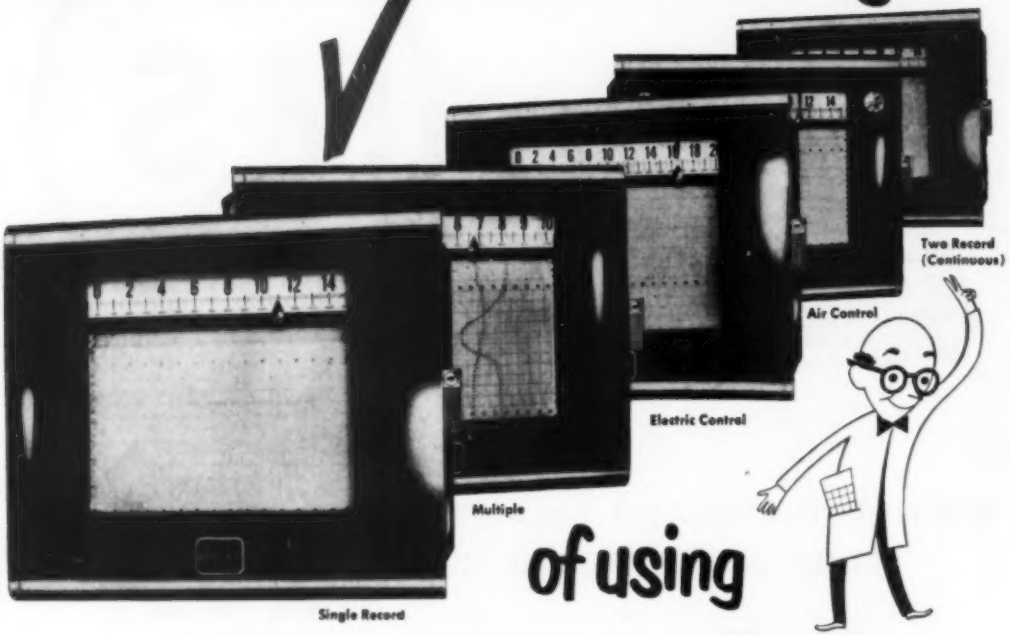

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Strip chart or circular chart recorders . . . recorders with slow or fast pen speeds and chart speeds . . . single or multiple recorders . . . automatic controllers . . . all in the same case with identical components except the chart-drive mechanisms.

This variety-with-standardization assures you of easier installation, better looking control panels, simpler maintenance. The service man who knows one Dynamaster, knows them all.

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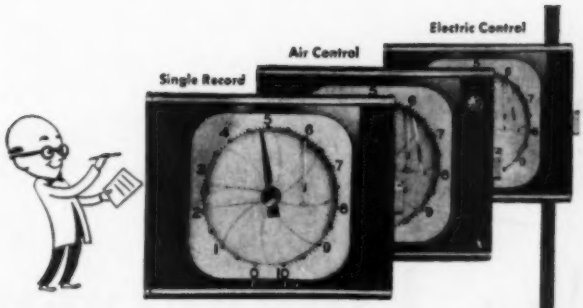
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



"Everyone who sees these Dynamasters is impressed with clean simplicity of internal design."

You'll be impressed too

WITH FEATURES LIKE THESE:

- Models to measure any variable convertible into d-c voltage, d-c current, resistance, capacitance
- Continuous-balancing electronic circuit assures instant response
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- All models use the same easy-to-replace components
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- Multiple recorders up to 16 points
- Practically immune to vibration, shock, or external stray currents

YOU'LL WANT TO GET *full details by using the coupon to order Catalog No. P1245.*

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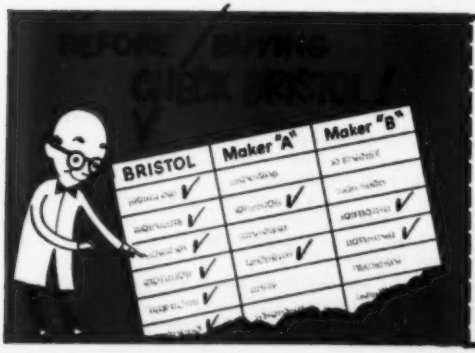


THE BRISTOL COMPANY
111 Bristol Road
Waterbury 20, Conn.

Please send catalog giving details of Dynamaster performance to:

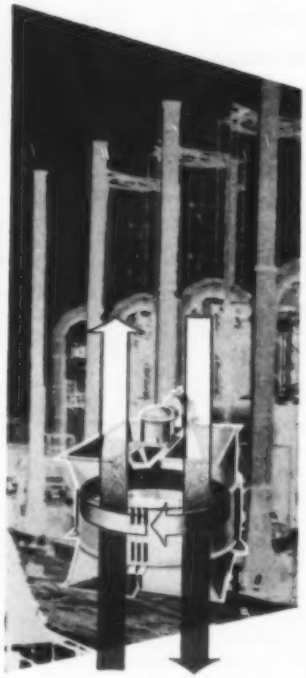
NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

GUIDEPOST TO ECONOMY...



The Ljungstrom operates on the continuous regenerative counter-flow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

The Ljungstrom Air Preheater

Every year, refineries consume over 200,000,000 barrels of fuel for processing crudes. This vast quantity of fuel represents probably the *greatest single item* in refinery operating expense. If lower costs are to be realized, serious thought must be given to heat-conservation equipment.

The Ljungstrom Air Preheater offers refiners a chance to save as much as *20% of the fuel needed for process work.*

This fuel saving, in addition to increasing production, makes the Ljungstrom an eminently practical piece of equipment to be considered wherever fuel is burned.

Check today to see how the Ljungstrom Air Preheater will pay for itself in just a few months – and give you impressive savings for many years. Call or write The Air Preheater Corporation for full details.

Wherever You Burn Fuel, You Need Ljungstrom

Refineries Now Using the Ljungstrom Air Preheater on One or More Process Units

Continental Oil Company
Interocean Oil Company
Le Conselho Nacional de Petroleo Ref.
Lion Oil Company
Ohio Oil Company
Richfield Oil Corporation
Sinclair Refining Company
Socony Vacuum Oil Company
Standard Oil Company of California
Standard Oil Company of New Jersey

The Ljungstrom is no stranger to refineries. For years it has been a standard item for utilizing waste heat from power and process steam boilers. These refiners now use Ljungstrom Air Preheaters on steam boilers . . .

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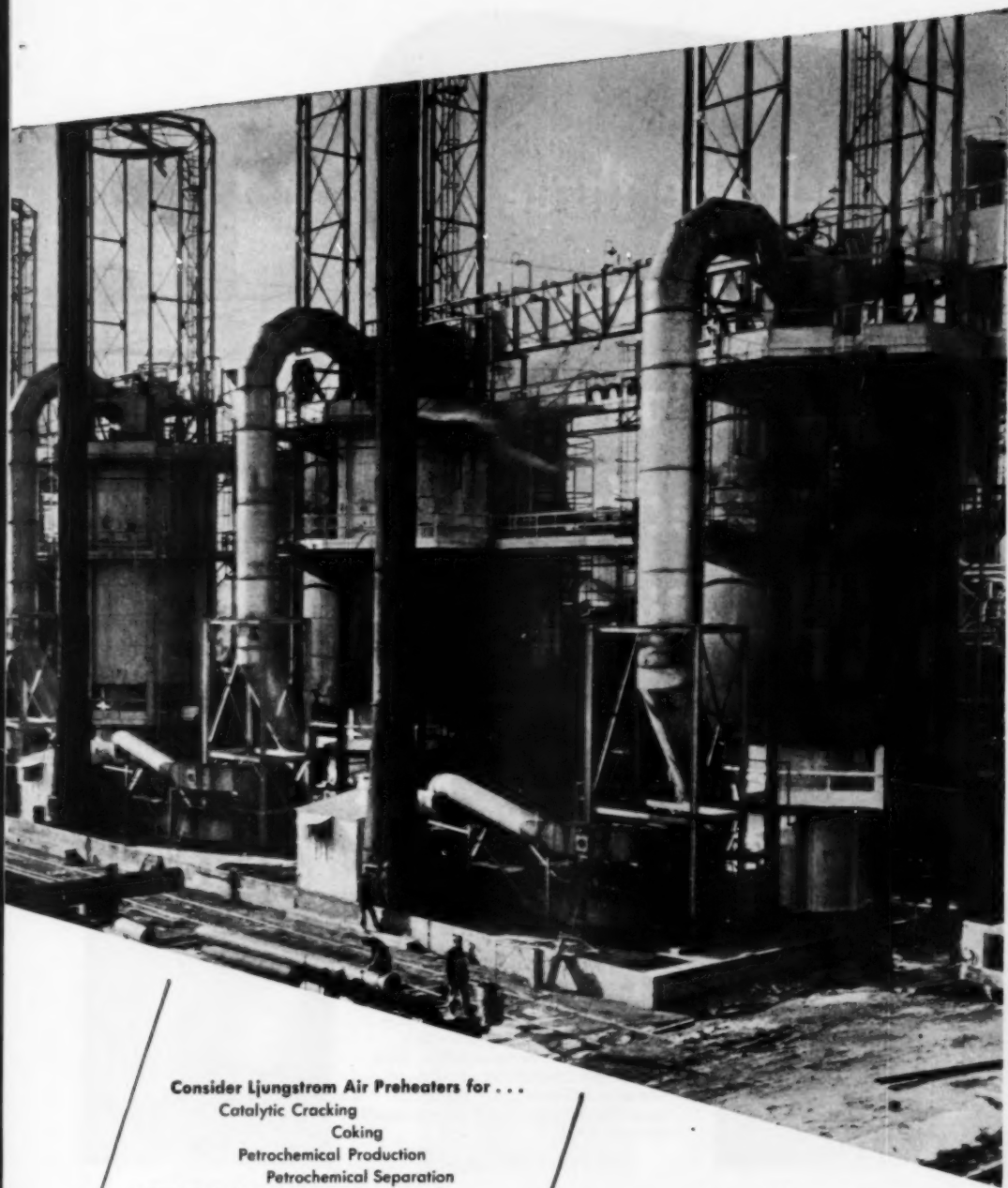
Continental Oil Corporation
Esso Standard Oil Company
Humble Oil & Refining Company
Magnolia Petroleum Corporation
Pan-American Refining Company
Phillips Petroleum Company
The Pure Oil Company
Shell Oil Company
Standard Oil Company of Indiana
Standard Oil Company of Louisiana
Standard Oil Company of New Jersey
The Texas Company
Tidewater Associated Oil Company
Wilshire Oil Company



Consider Ljungstrom Air Preheaters for . . .

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Petrochemical Separation
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Reforming
Solvent Refining
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THE AIR PREHEATER CORPORATION
60 East 42nd Street, New York 17, N. Y.

Check the three big reasons why it pays to specify Eagle-Picher Insulation:

1.

2.

3.

Eagle-Picher "66" Insulating Cement— All-purpose, rust-inhibitive, super-adhesive insulating cement. Great coverage, extreme thermal efficiency with "Springy Ball" pellets which won't collapse after application. Easy trowel application over all kinds of surfaces. Efficient up to 1800 F... reclaimable where temperatures do not exceed 1200 F.

THE EAGLE-PICHER

Cost-cutting insulations of top thermal efficiency

Insulating Cements

Fireproofing Cements

Supertemp Block

Blankets

Insulseal

Stalastic

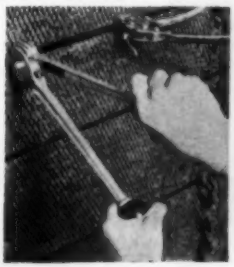
Dependable contractors, trained to strict factory standards

You can count on Eagle-Picher authorized contractors for uniformly high caliber service. Their qualifications provide assurance of a good job *every time* . . . efficient application of the Eagle-Picher insulation that best fits your needs.

Fast delivery from strategically located distribution points

The Eagle-Picher insulation line is stocked by distributors and authorized contractors coast to coast. The one nearest you will be happy to recommend insulating materials that give your equipment highest thermal efficiency . . . reduce fuel costs . . . help provide precise temperature control.

Eagle-Picher Supertemp Blocks—
A real insulating block—not a refractory! Unequalled for insulating quality. Weighs approximately 16 lbs. per cu. ft. Cuts easily with knife or saw . . . fits snugly over contoured surfaces. Monolithic structure . . . high refractory value. Withstands temperatures up to 1700 F. All standard sizes, from 3" x 18" to 12" x 36" . . . in thicknesses from 1" to 4".



Eagle-Picher Mineral Wool Blankets—
Made under factory supervision, these blankets fill your needs for fast, convenient insulating of flat or curved surfaces on larger types of heated equipment. The wool is felted and secured by flexible metal fabric . . . possesses outstanding physical and chemical stability for maximum resistance to water, steam, corrosive fumes and vibration.

COMPANY EAGLE EP PICHER

General offices: Cincinnati (1), Ohio
Insulation products of efficient mineral wool—for a full range of high and low temperatures. Technical data on request.

Vogt

WELDED PRESSURE VESSELS

Top quality power and process plant equipment for safe operation at high or low pressures and temperatures is produced here for leading Petroleum Refineries, Chemical Plants, and Power Plants the world around.

A growing preference for Vogt welded pressure vessels is due to skilled personnel, powerful X-ray apparatus to control weld quality and modern stress relieving furnaces, combined with complete laboratory facilities for tests of welds.

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CARBON STEEL and ALLOY STEELS

HENRY VOGT MACHINE CO.
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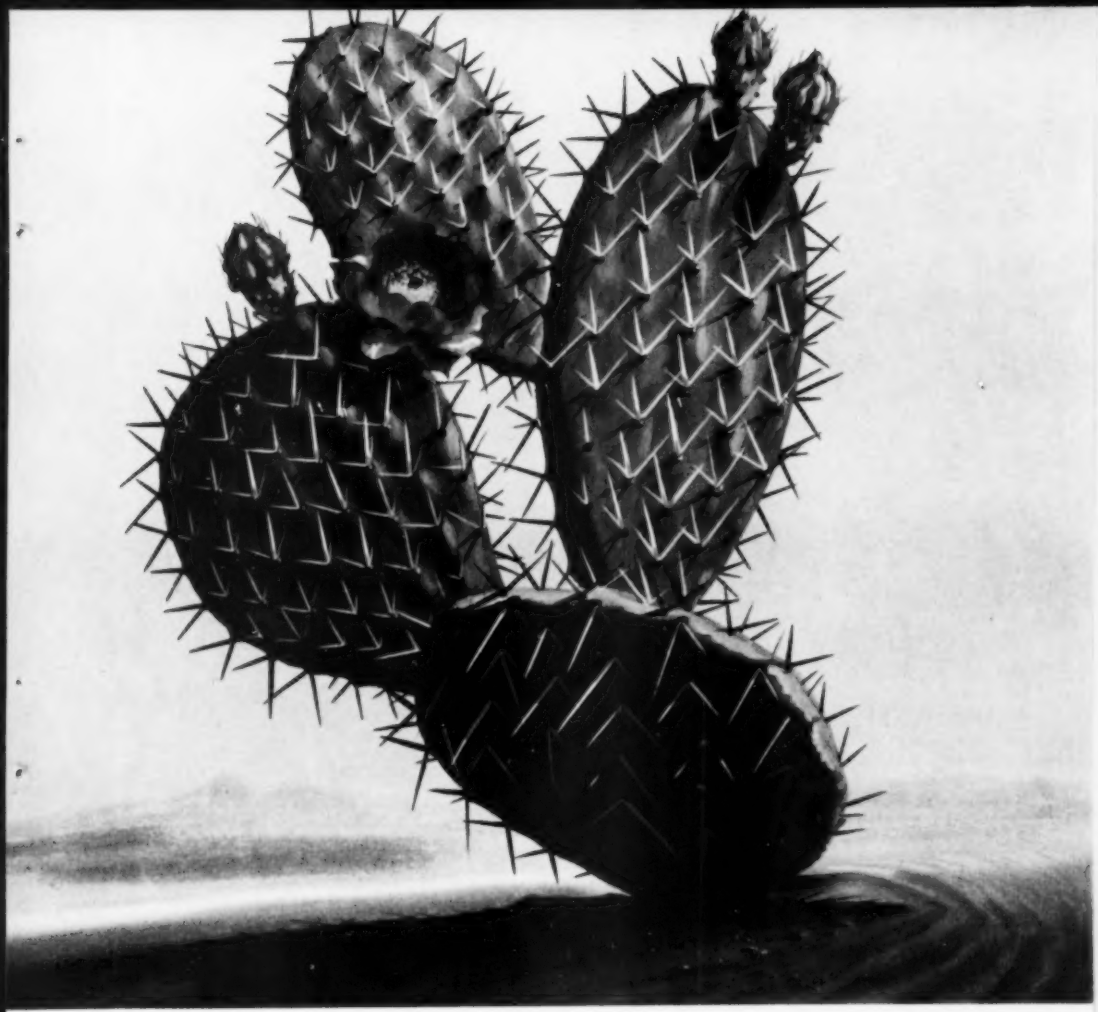
BRANCH OFFICES: NEW YORK, PHILADELPHIA, CLEVELAND, CHICAGO, ST. LOUIS, DALLAS



What is the most important point about our new Texas plant?

It probably would be more usual to announce the opening of Ethyl's new Texas plant by showing a large air view of the entire layout. However, this close-up of another kind of Texas plant better illustrates our point.

You see, the plant in the picture above is completely self-sustaining. Just give it sunlight, air, a little water, and a place to grow. It depends only upon raw materials to make the complex chemicals it needs to stay in business. In other words, it is a *completely integrated* plant . . . just like the new Ethyl plant at Houston, Texas.

Give Ethyl's new Texas plant the raw materials—such as pig lead, salt, petroleum gases, electricity—and it can make all the chemical ingredients needed in "Ethyl" antiknock compound. In this way the new plant is like Ethyl's plant

(*continued on next page*)

What is the most important point about our new Texas plant?

(*continued from preceding page*)

at Baton Rouge. Each is completely integrated—and is independent of the other.

We think this integration is an extremely important point to refiners. Today refiners are faced with the challenge of supplying great quantities of high-quality gasoline to meet the ever-increasing demands of American transportation. To perform this service, they need an uninterrupted supply of antiknock compound —which an *integrated* plant is best able to give them.

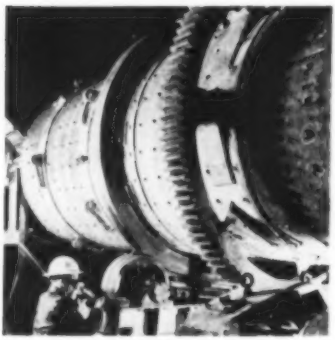
With the construction of Ethyl's new Texas plant, such a reliable source of antiknock compound is now assured. The new plant is engineered for highest efficiency. Raw materials are available nearby. Electric power supplies are ample. Six railroads out of Houston give Ethyl wide choice in routing antiknock compounds to Ethyl customers throughout the country. And, perhaps most important, this new plant has expanded facilities to a point where "Ethyl" antiknock compound manufacturing capacity is now more than ample to meet demand in the foreseeable future.

ETHYL CORPORATION

NEW YORK 17, NEW YORK

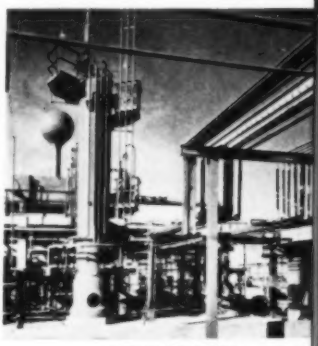
Ethyl service is backed by 29 years of antiknock experience

HERE ARE A FEW OF THE MANUFACTURING UNITS IN OUR NEW TEXAS PLANT



A SALT DRYER IN THE SODIUM BUILDING

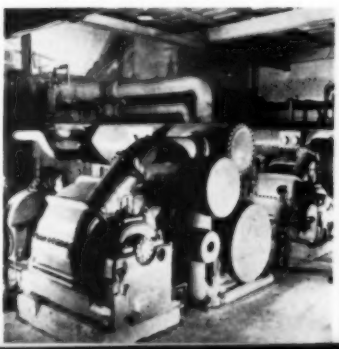
HIGH-VOLTAGE LINE FOR SODIUM CELLS



THIS IS THE ETHYL DICHLORIDE PLANT

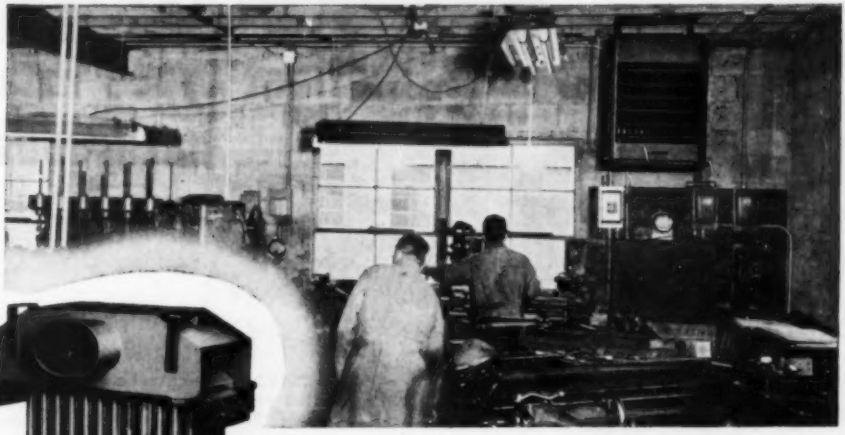
THE ETHYL CHLORIDE UNIT IS A PLANT IN ITSELF

REFRIGERATION COMPRESSORS IN THE ETHYL CHLORIDE UNIT



TETRAETHYLLEAD MANUFACTURING BUILDING

HOW THE ROAR OF A JET LED TO A BETTER UNIT HEATER



Stainless Steel heat exchanger and burner assembly of Modine gas-fired unit heater.

ENDURO makes new Modine heater more durable, lighter, faster-acting

The use of heat-resisting stainless steel for jet engine exhaust parts gave Modine Manufacturing Company engineers an *idea.* Although gas-fired unit heaters never are subjected to jet engine temperatures or corrosive conditions, they are vulnerable to similar service hazards.

In new Modine models, Republic ENDURO Stainless Steel is used for heat exchangers and burners. From now on, ENDURO construction will *combat these former heater hazards*—corrosion due to gas acids and contaminated atmospheres . . . high-temperature scaling and flaking, which weakened metal walls and clogged burners . . . rusting caused by condensation and atmospheric moisture . . . cracking . . . and rapid discoloration.

In addition, ENDURO has saved 50 to 200 pounds of weight per unit by permitting lighter gauge construction of exchangers and burners. And, with metal mass reduced, tube warm-up lag is minimized. Tests show that the new units actually deliver heat *within 5 seconds* of the thermostat's signal.

Petroleum process equipment, of course, is subject to similar operating hazards. ENDURO Stainless and Heat-Resisting Steels can help overcome them for you, too. And, Republic metallurgists are ready to work with you, and with your equipment suppliers, in adapting ENDURO to your own ideas. Call your nearest Republic District Sales Office, or write:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, N.Y.

Republic
REPUBLIC STEEL
ENDURO STAINLESS STEEL

Other Republic Products include Upson Bolts, Studs, Nuts and Rivets—Pipe—Sheets—Plates—Electrunite Heat Exchanger Tubes

CROUSE-HINDS
PLUGS and

Two distinct types in a wide hazardous area

Both types have been service tested through the years for continued safe and dependable use. Both are approved by Underwriters' Laboratories, Inc. . . . Type CES for atmospheres containing explosive gases or vapors and Type FSQ for either explosive or dusty atmospheres. You can rely on both types for the safe connection of portable electrical equipment in such hazardous locations.

Type CES

1. Crouse-Hinds famous *Arktite* design . . . circuit-breaking at full load . . . no disconnect switch required.

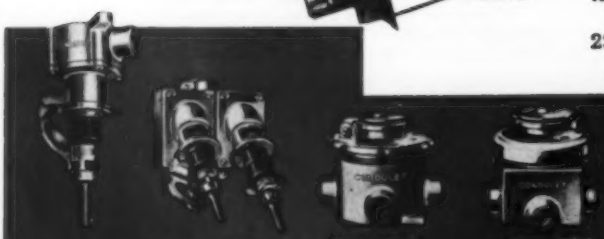
2. Plugs can be used in non-explosion-proof *Arktite* receptacles, permitting the use of special explosion-proof portable equipment and tools in non-hazardous locations. However, non-hazardous equipment cannot be used in hazardous areas because Type CES Explosion-Proof Receptacles will not accept the regular *Arktite* plugs.

3. Simple delayed action feature . . . insert plug, twist . . . push. Contacts make and break in tight explosion-proof chamber without enough oxygen to maintain the arc.

4. Pigtails in splice box . . . factory sealed to contain any explosion.

5. Up to 30-Amp., 460-Volt, A. C.; 60-Amp., 230-Volt, A. C., single and 3-phase.

6. Explosion-proof.



← Other explosion-proof *Arktite* receptacles similar to CES.

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CONDULETS • TRAFFIC SIGNALS

Explosion-Proof and Dust-Tight RECEPTACLES

range of sizes to meet your requirements

interlocked switch Type FSQ
Explosion-Proof, Dust-Tight

Type FSQ

1. Has built-in interlocked disconnect switch . . . no separate disconnect required.

2. Simple, sure dead front action . . . insert plug and twist to turn on switch . . . twist to withdraw plug. Twisting operates built-in switch. Plugs cannot be inserted or withdrawn with switch "ON".

3. The threaded cover can only be removed when the switch is "OFF" and the switch cannot be turned "ON" until the cover is on and locked in position by a special screw.

4. Up to 30-Amp., 460-Volt, A. C. single and 3-phase; or 250-Volt, D. C.

5. Explosion-proof and dust-tight.

Look for the complete listings in your Condulet Catalog, or send for full information.

CROUSE-HINDS COMPANY
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Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.

Interlocking Switch
Switch Operating Arm
Rotating Receptacle Assembly
Contacts
Plug
Cable

Other explosion-proof and dust-tight receptacles with interlocked switches or circuit breakers. →

Type FSQ 10-Ampere | Type DBR Up to 100-Ampere (Dust-Tight Only) | Type EPC Up to 100-Ampere | Type EPC Up to 200-Ampere

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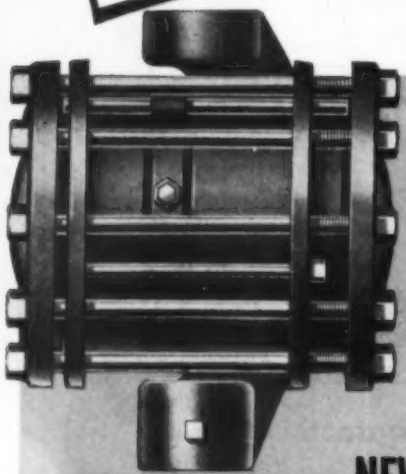
Another AMERICAN® Advance

THE NEW

A MERCURYLESS METAL SUPPLEMENTING



AMERICAN METER'S NEW DIFFERENTIAL PRESSURE MEASUREMENT INSTRUMENT—

Adaptable to all American Pneumatic Controllers, Transmitters, Differential Valves, Telemeters and related instruments.

For differential pressure applications where accurate measurement is required without the use of a mercury manometer, American Meter Company now offers a bellows actuated instrument designed and built with characteristic American precision in ranges of 50", 100" and 200" for working pressures to 1,000 P.S.I. These new instruments are designed for ease of installation, accurate performance and minimum maintenance under rugged operating conditions.

• • •

Range changes are made easily and simply by removal of the low-side cover for access to the range spring without disturbing the high-side cover or any connections. Calibration, virtually tamper-proof since all adjustments are internal, is readily performed by applying the differential pressure on the high-side with low-side cover removed. Damage or distortion to the bellows due to sudden over-range is prevented by stick-proof check valves with flat, synthetic seats. An additional bellows compensates for volume changes in bellows filling fluid resulting from ambient temperature variations. The Teflon-sealed pulsation dampener, for accurate control of instrument response, is externally adjustable under pressure.

• • •

American is and will continue to be the first name in metering dependability. For complete information on this latest addition to the American line . . . built with the precision and extreme care characteristic of American Meter Company's century-old tradition of "Sustained Accuracy at Lower Cost" . . .

Write for Specifications or Call the Nearest Office Listed Below

NO PRECISE LEVELLING — NO SEAL POTS REQUIRED
Pedestal, Panel or Overhead Hanger Mounting
— Top and Bottom Gage Line Connections

FOR WORKING PRESSURES TO 1,000 P.S.I.
— AMBIENT TEMPERATURES OF
—25° TO 175°F.

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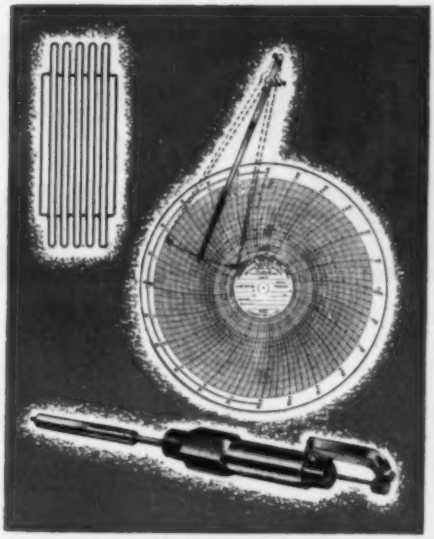
DRI-FLO ORIFICE METER

BELLOWS DIFFERENTIAL PRESSURE INSTRUMENT

THE AMERICAN WESTCOTT MERCURY MANOMETER ORIFICE METERS



- **ONE-PIECE STAINLESS STEEL BELLOWS CONSTRUCTION**

  Large area, fluid filled, *seamless* stainless steel bellows provide longer service life with minimum possibility of leaks caused by metal fatigue.

- **DIRECT FULL SCALE RECORDING PEN MOVEMENT— NO EXTERNAL GEARING OR LINKAGE MULTIPLICATION**

  Recording pen arm travels through the full 22½ degree arc without complex external gearing or linkage multiplication. Standard American Westcott charts are used.

- **AMERICAN TYPE "B" TEFLON SEAL STUFFING BOX NEEDS NO LUBRICATION**

  Noted for simplicity, this nearly frictionless precision unit provides maximum accuracy . . . *Requires No Lubrication.* All stuffing box parts are removable and replaceable in the field . . . *No Shaft Freezing; No Leakage.*

- **STAINLESS STEEL INTERNAL WORKING PARTS**

  All internal operating parts of the new DRI-FLO Orifice Meter are of stainless steel except the ground and polished stuffing box shaft which is Monel metal. Body is cast steel.

- **READILY ACCESSIBLE FOR CLEANING**

  The meter body and internal working parts are easily accessible for inspection, calibration and cleaning by removing one or both case cover heads . . . without disturbing manifold piping.

AMERICAN METER COMPANY
INCORPORATED ESTABLISHED 1836

AMERICAN METER COMPANY EST. 1836 MEASUREMENT ENGINEERS

The Logical "Next-step" in Economy and Efficiency . . .

GHT-LINE CATALYST FLOW . . . THE CRACKER WITH STRAIGHT-LINE CATALY
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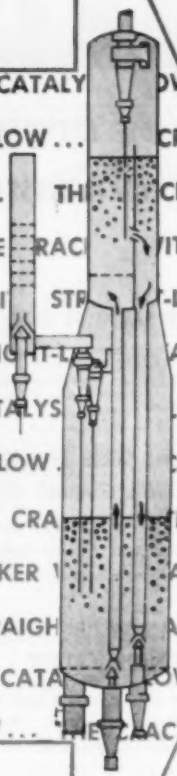
LYST FLOW . . . THE CRACKER WITH STRAIGHT-LINE CATALYST FLOW . . .

Kellogg Orthoflow



ORTHOFLOW, the latest Kellogg advancement in Fluid catalytic cracking, not only merges reactor and regenerator into a single vessel, but provides *straight-line transmission* for both catalyst-oil mixture and spent catalyst—in a system free from slide-valves and expansion joints.

As a result, **Orthoflow** costs less to build, costs less to maintain and is more flexible in operation. It requires less structural steel, smaller foundations, simplified piping. Straight-line catalyst flow minimizes erosion and increases efficiency.

An **Orthoflow** unit can handle practically any feed-stock, from kerosene to the heaviest gas oil. High-boiling stocks are charged as liquids and vaporized by the hot catalyst, with minimum use of pre-heat facilities. Furthermore, **Orthoflow** units permit wide latitude in conversion . . . operate effectively over a wide range of feed rates to meet changes in a refinery's requirements.

Orthoflow, the logical "next-step" in catalytic cracking progress, derives from Kellogg's basic experience—dating from the inception of Fluid catalytic cracking—and the engineering of more than 70 percent of the world's total Fluid cracking capacity.

The latest issue of the KELLOGGRAM —"From Baton Rouge to Orthoflow"— presents the details on this new cracking development. Available on request.

THE M. W. KELLOGG COMPANY

(A Subsidiary of Pullman Incorporated)

NEW YORK JERSEY CITY LOS ANGELES TULSA HOUSTON TORONTO LONDON PARIS

KELLOGG

PROGRESS REPORT

ORTHOFLOW CATALYTIC CRACKERS

UNITS OPERATING:

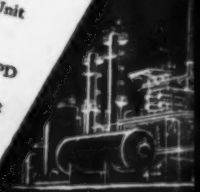
In Western Canada— 2,500 BPD Unit
In Mid-Continent U. S.—8,300 BPD Unit

UNITS UNDER CONSTRUCTION:

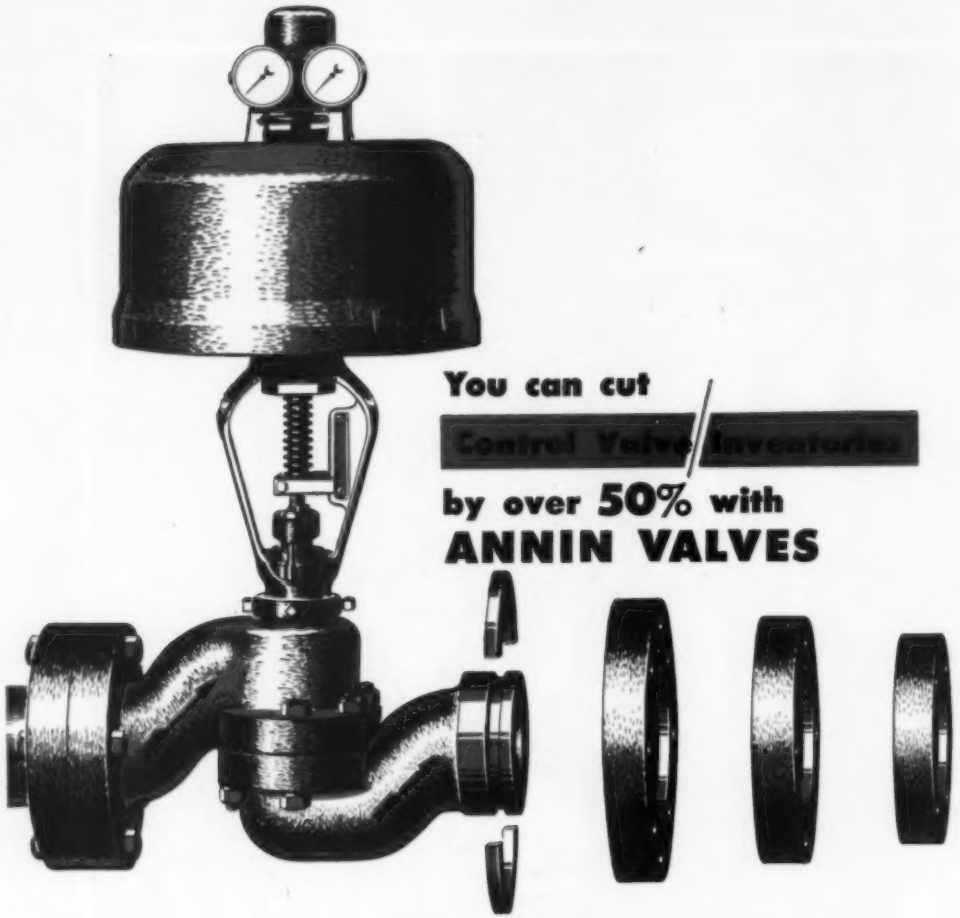
In Eastern Canada—8,300 BPD Unit

UNITS IN ENGINEERING:

On the Atlantic Seaboard—28,000 BPD Unit
In Mid-Western U. S.—17,000 BPD Unit
On the Gulf Coast—26,000 BPD Unit
In Europe—5,000 BPD Unit



.....for fifty one years an integral part of petroleum refining progress!



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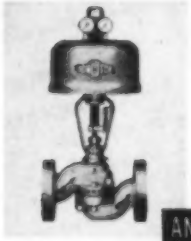
Control Valve Inventories

by over 50% with

ANNIN VALVES

Designed for maximum interchangeability of valve bodies, flanges and operators



The Annin Domotor valves provide positive control of corrosive, erosive fluids and fluids containing semi-solids.

Because all Annin valve bodies carry 1000# ratings, interchangeable flanges in Series 15, 30 and 60 can be mounted with split-rings on any Annin valve body to meet the requirements of practically any installation. One body, mounted with proper flanges, can be used anywhere in the plant. In addition, any Annin operator—Domotor, Electro-Pneumatic, Handwheel—fits *two* sizes of any valve body. Thus it is unnecessary to stock spares for *every* valve type and size you use. Most Annin users report great reductions in necessary valve stocks from 50% to 75% and more!

This reduction in inventory, *plus* considerable reductions in maintenance costs make the Annin Valve one of the most economical to operate in your plant. It will pay you to investigate today the many advantages of Annin Control Valves. Send for Catalog 1500B.

Annin Catalog 1500B describes all Annin Valves, tells how Annins reduce inventories and cut maintenance costs. Send for your copy *today!*

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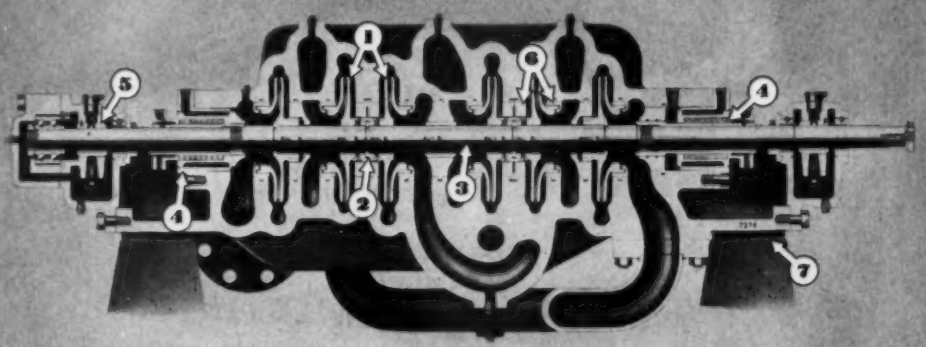
THE ANNIN COMPANY 3500 Union Pacific Avenue, Los Angeles 33, Calif.

Simplicity, long life, easy maintenance

CAPACITIES TO 1000 GPM
PRESSURES TO 1200 PSI
TEMPERATURES TO 350-400F

1. Opposed impellers balance axial thrust.
2. Impeller mounting provides leak-proof shaft sealing between stages.
3. Exposed shaft insures freedom from distortion.
4. Removable stuffing boxes permit flexibility in shaft sealing arrangement.
5. Split sleeve radial bearings are standard.
6. Positive interstage wearing ring seals eliminate leakage.
7. Casing support insures coupling alignment.



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OPPELLER PUMPS

Look at the seven outstanding features shown in the cross-section and you'll see why De Laval Refinery Pumps stay on the line for years...trim maintenance costs. Use these pumps for service up to approximately 1,000 gpm and 1,200 psi with temperature up to 350-400F. They can handle liquids ranging from propane to strong caustic. Write today for bulletin giving full application and specification data.

Refinery Pumps

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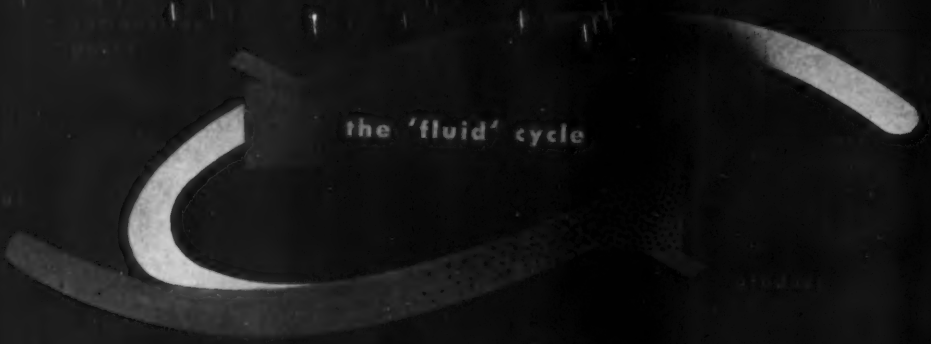
catalytic reforming



catalytic cracking

Whether in Fluid Catalytic Cracking or Fluid Catalytic Reforming, the 'fluid' system for catalyst control and heat addition represents the most flexible operating technique in the history of refining crude petroleum.

Flexibility in control of catalyst-oil ratios, in temperature and time functions, . . . in processing charge stocks of wide variation in quality, . . . plus . . . continuous operation over extended periods of time . . . are invaluable operating assets that add-up to one final result: the maximum production of high-octane gasoline per dollar invested.

Our latest brochure, . . . "FLUID HYDROFORMING" is available now. Send for your copy — O-52-3 to the:

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● VALVES

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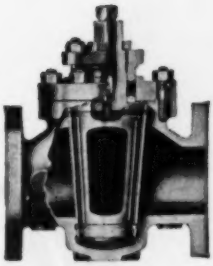
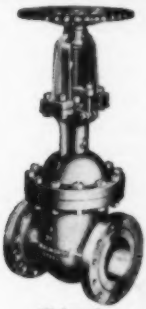


Walworth
Lubricated Plug Valve



Walworth
Steel Gate Valve

Walworth
Iron Body Gate Valve

Walworth
"500 Brinell" Bronze Globe Valve

Walworth
Iron Body Saddle Gate Valve

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Walworth manufactures a *complete line* of valves and pipe fittings: all made to the highest standards of quality, both as to dimensional accuracy and metallurgical properties. In design, construction, and performance, Walworth products reflect more than a century of experience in the manufacture of quality valves and fittings.

Your Walworth distributor will give you full information on the *complete line* of Walworth steel, iron, and bronze, and special alloy valves and pipe fittings; also Walworth Lubricated Plug Valves, and Walseal* valves, fittings and flanges. Ask for this information today.

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NEW
FLUID CAT CRACKER....

for THE BAY PETROLEUM CORPORATION
Chalmette Refinery . . .

BUILT BY PROCON

Completed within nine months, this 5600 b/d UOP Fluid Catalytic Cracking Unit was built by Procon for The Bay Petroleum Corporation, Chalmette (La.) refinery with less than 30 days' interruption in plant operations. Shut-down time was minimized by fast work in converting existing equipment to use with the new cracker.

While this new unit was still under construction, Bay Petroleum placed an order with Procon for a second UOP fluid cat cracker to be built at their Denver refinery. Such confidence is convincing evidence of Procon's ability and facilities to handle any refinery or petro-chemical plant construction job.

PROCON *Incorporated*

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(A Quick Quiz on modern pH advancements)

Do you know these important facts about BECKMAN pH CONTROL?

Do you know...

That Beckman pioneered modern glass electrode pH equipment?

Until Beckman pH instruments were developed, glass electrode pH equipment was a cumbersome, complicated laboratory curiosity. It was Beckman that pioneered today's simple, compact, highly accurate and completely dependable glass electrode pH equipment!

That Beckman pioneered virtually every major development in modern glass electrode pH equipment?

Such far-reaching advancements as the High pH Glass Electrode . . . the High Temperature Glass Electrode . . . the Unusually Rugged "X-9" Glass Electrode . . . as well as a wide range of other vitally important advancements in glass electrode pH instrumentation, were *all* pioneered by Beckman. *Many of these advancements are still available exclusively in Beckman equipment!*

That Beckman offers the industry's most complete line of glass electrode pH instruments?

Included in the complete Beckman line are instruments specially designed to combine the high precision and wide versatility necessary for advanced research, medical and laboratory applications . . . others that combine maximum simplicity and high accuracy with complete portability for plant and field applications . . . still others that combine maximum simplicity and high accuracy with the plug-in convenience of full AC operation . . . plus *completely automatic* pH equipment for continuous pH indication, recording and control on large-scale processing applications.

That Beckman also provides the industry's most complete line of modern glass electrodes?

Although glass electrode pH instruments are the most efficient pH equipment obtainable, no glass electrode pH instrument is better than the versatility, accuracy and dependability of the electrode assemblies available for use with it.

Beckman provides the industry's most complete line of glass electrodes for use with Beckman pH instruments—a type of electrode assembly to meet every industrial, research, laboratory and field requirement!

That there are so many money-saving applications for Beckman pH control that you may be losing important profits unless you make a complete investigation of your operations?

There is pH wherever there's water, water solutions, moist pastes, sludges, slurries or other moisture-containing substances. And wherever there is pH, chances are the operation can be done better . . . with greater uniformity and less waste at lower overall cost . . . by Beckman-controlling the pH of the various processing operations.

WHETHER you manufacture food products or treat sewage . . . do metal plating or refine crude oil . . . make textiles or process ore—in fact, no matter WHAT your field of operation . . . if you have not yet determined whether Beckman pH Control can be used to advantage in your operations—possibly is already BEING used to cut costs by your competitors—let us study your processes and make helpful recommendations. No obligation, of course. BECKMAN INSTRUMENTS INC., SOUTH PASADENA 25, CALIFORNIA. Factory Service Branches: New York, Chicago, Los Angeles.

For an informative, non-technical outline of modern pH control — what it is and how it's used — send for this free booklet "What Every Executive Should Know About pH." Ask for Bulletin 1—131

BECKMAN

INSTRUMENTS CONTROL MODERN INDUSTRIES

pH Meters and Electrodes — Spectrophotometers — Radiation Meters — Special Analytical Instruments

WeldELLS®

...have set their own standards

Many of the largest users of Welding fittings refuse to accept any other fittings than WeldELLS.

They have found that when the name, WeldELL, is stamped into a fitting, that fitting can be accepted without question for any service for which it is designed.

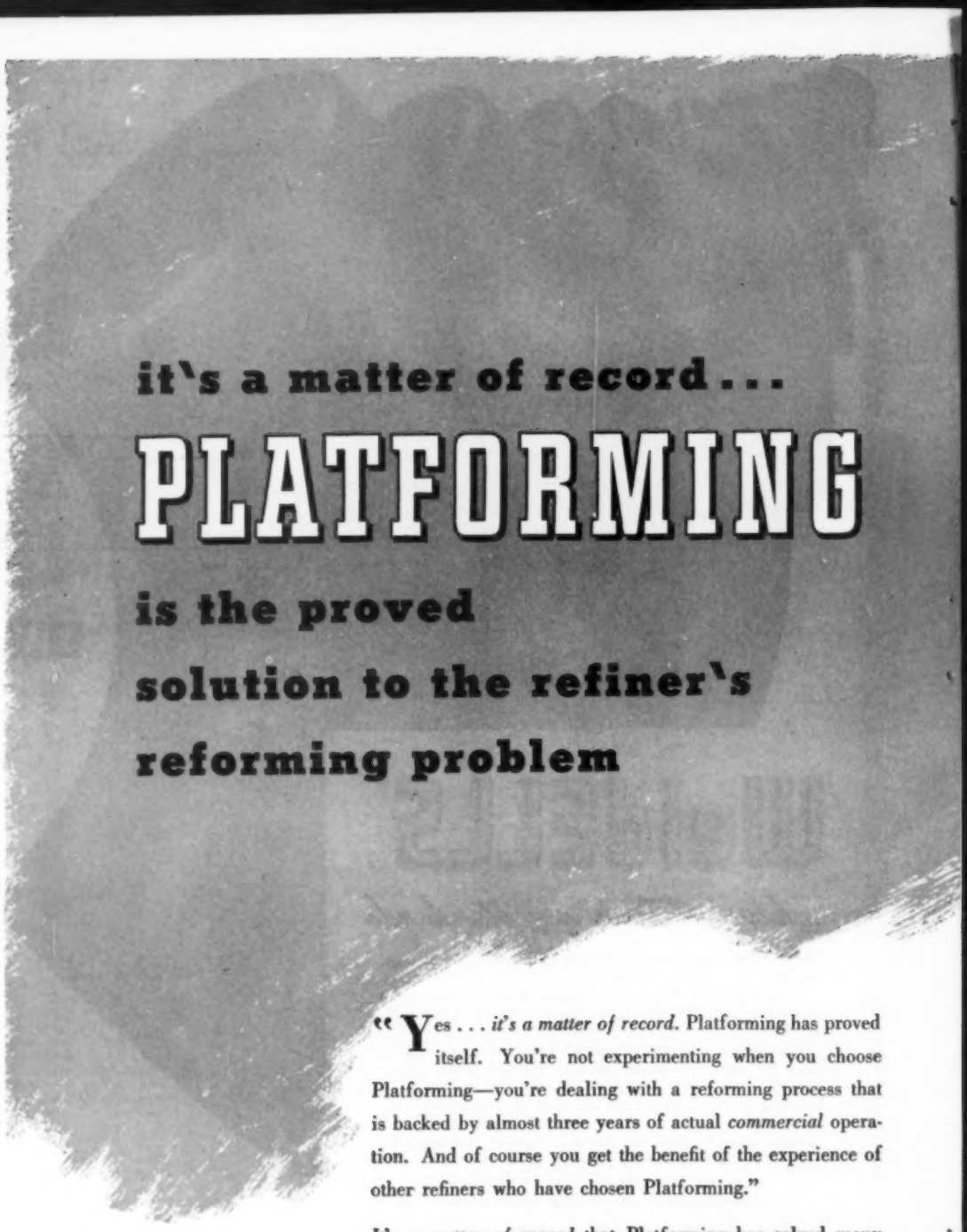
They have found that WeldELLS have features that please both the men who design and the men who erect welded piping . . . features that were pioneered by Taylor Forge . . . features that are combined in no other welding fittings.

They have found the answer to their every need in the greater range of sizes, weights and types of the WeldELL line . . . in the broader scope of materials.

Ask for up-to-the-minute facts about WeldELLS and Taylor Forged Steel Flanges.

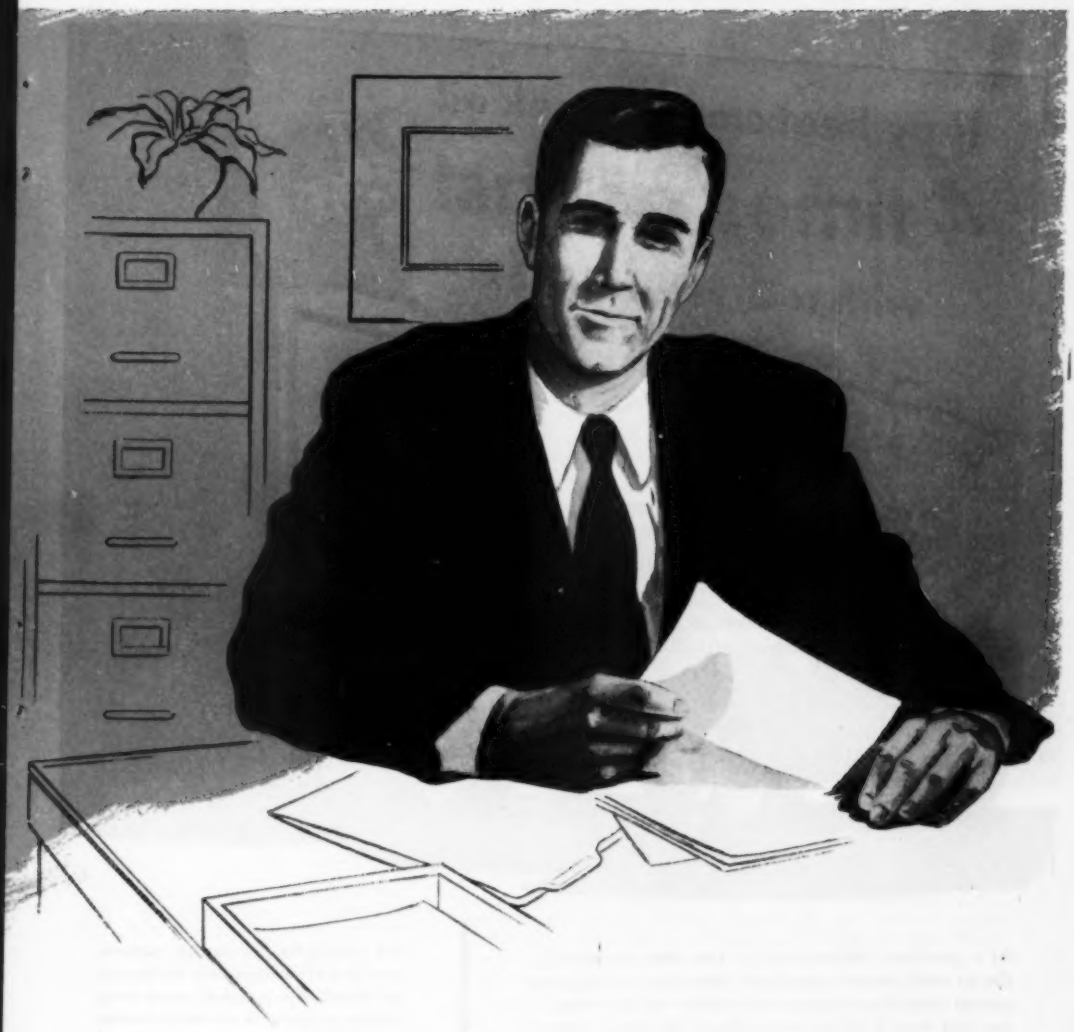
TAYLOR FORGE

TAYLOR FORGE & PIPE WORKS, General Offices and Works: P.O. Box 485, Chicago 90, Ill.
Offices in all principal cities. Plants at: Carnegie, Pa.; Fontana, Calif.; Hamilton, Ont., Canada



"Yes . . . *it's a matter of record.* Platforming has proved itself. You're not experimenting when you choose Platforming—you're dealing with a reforming process that is backed by almost three years of actual *commercial* operation. And of course you get the benefit of the experience of other refiners who have chosen Platforming."

It's a matter of record that Platforming has solved many problems presented in various field conditions and it has met the complexities of a wide range of charge stocks. It's rugged and adaptable.



It's a matter of record that more than one refiner has met the demand for premium gasoline by merely increasing the severity of processing conditions and producing a higher octane Platformate . . . and that sales departments thank Platformed gasoline for wider markets and bigger gallonage.

Yes, Platforming is the proved reforming process . . . proved and approved by the petroleum industry. *It's a matter of record.*

UNIVERSAL OIL PRODUCTS COMPANY

General Offices: 310 S. MICHIGAN AVE., CHICAGO 4, ILL., U.S.A.
LABORATORIES: RIVERSIDE, ILLINOIS

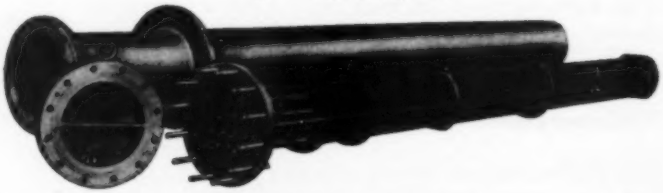
Universal Service Protects Your Refinery

They heat storage tank oil
4 times as fast
with a G-FIN HEATER

At a petroleum refinery near an east coast community, the oil truck drivers complained about the hour-long turn-around time. They pointed to a nearby refinery where the cold viscous oil in storage tanks was being heated much quicker.

The refinery manager checked, found the other refinery was using G-Fin Storage Tank Oil Heaters, and ordered them for his own tanks. Result . . . the oil was made to flow so much faster that truck turn-around time was cut from 1 hour to 15 minutes.

The reasons for this superior performance of G-Fin Storage Tank Oil Heaters are described in a bulletin which every refinery executive in charge of loading racks and blending stations should have. Write for a copy, without obligation of any kind.

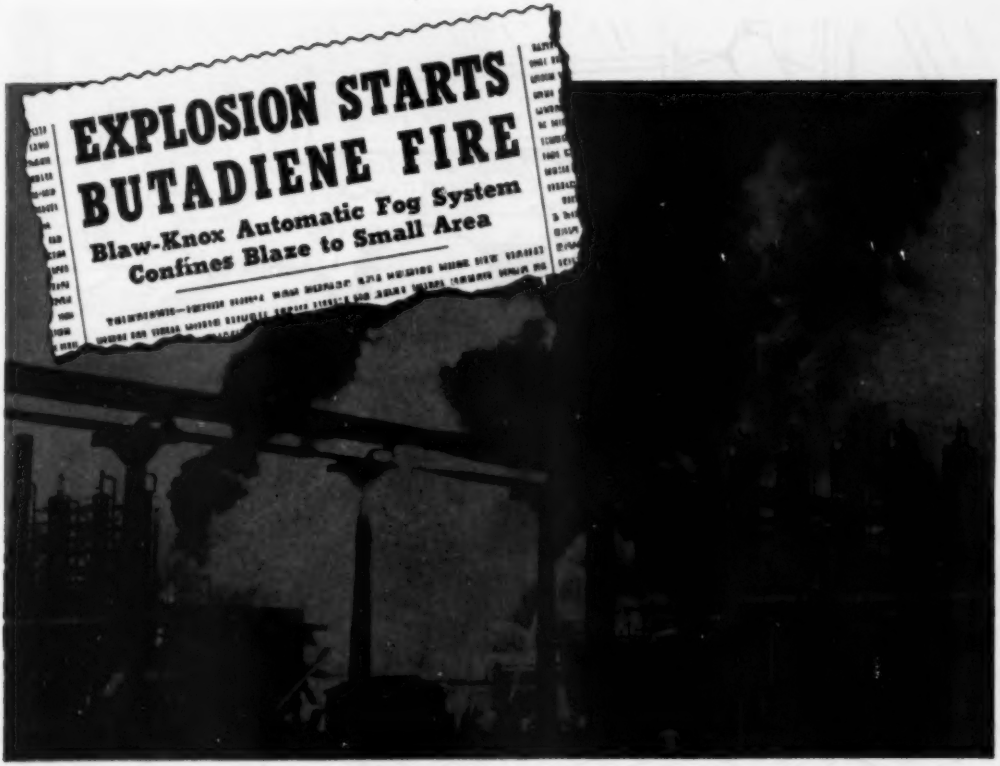


THE GRISCOM-RUSSELL CO., MASSILLON, OHIO

GR 269

GRISCOM-RUSSELL

PIONEERS IN HEAT TRANSFER APPARATUS



A serious fire, yes, but no "total loss"—thanks to the protection of adjacent equipment by smothering blankets of water from a

BLAW-KNOX AUTOMATIC FOG SYSTEM

Actuated by rate-of-rise thermostats, this system sounds an alarm and instantly throws a dense, quenching fog of water on the danger spot—either extinguishing or controlling the blaze while protecting adjacent equipment.

A Blaw-Knox System engineered for the fire hazards existing in or around your plant is a most effective weapon against fire's toll. Your insurance savings as they accrue applied to its cost—provide you with the utmost in fire protection plus a good financial investment . . . Glad to consult with you and submit an estimate without obligation.

BLAW-KNOX SPRINKLER DIVISION
of BLAW-KNOX CONSTRUCTION COMPANY
829 Beaver Ave., N.S., Pittsburgh 33, Pa.
Offices in Principal Cities

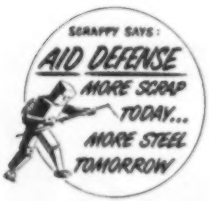
Deluge Systems, Wet Pipe Systems, Dry Pipe Systems, Water Spray and Fog Systems, Rate-of-Rise Sprinkler Systems, and Foam and Carbon Dioxide Extinguisher Systems.

"LITTLE JOEY SPRINKLER"
Always on the Job

BLAW-KNOX

AUTOMATIC FIRE PROTECTION SYSTEMS

Grandpa Never Threw a Thing Away



It's only human to want to hold on to things after they've outlived their usefulness. That's why today millions of tons of worn-out and obsolete equipment and machinery are lying forgotten in the country's plants and factories and on farms.

The steel industry needs these millions of tons of dormant scrap, needs it in the worst way. With this vital dormant scrap the entire steel supply picture would brighten up, with more steel for everybody. But without it, the steel industry cannot hope to keep up production at present levels.

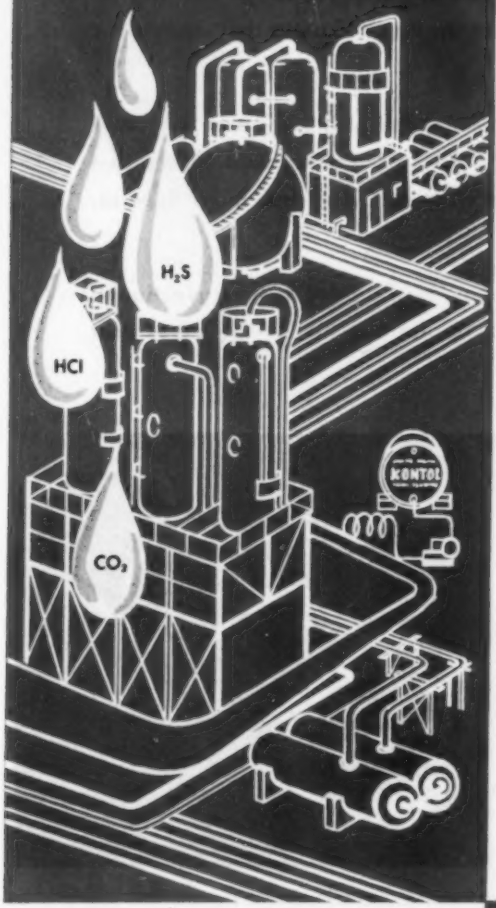
Call in a scrap dealer now, today. He will buy your dormant scrap and start it moving toward the steel mills.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

More Scrap Today...More Steel Tomorrow

STOP CORROSION LOSSES



KONTOL

Corrosion Inhibitor is used effectively in the refinery to combat corrosion caused by moisture, chlorides, HCl, CO_2, H_2S and organic acids. Kontol inhibits attack by H_2S, stopping blister formation at its source.

KONTOL can be used to control the corrosion of flow lines, fractionating towers, debutanizers, depropanizers, and stripping columns. It is also effective in the protection of heat exchangers, gathering systems, separators, scrubbers and overhead products lines.

KONTOL does not affect the quality of refined products, with reference to end point, gum-formation, anti-knock rating, color, ash content and so on.

KONTOL can be continuously injected into a refinery flow system by means of a chemical feed pump, or by once-p-day batch injection by means of a lubricating device.

KONTOL provides protection against corrosion by adsorbing at metal surfaces as a thin, tough, impervious film which prevents contact by corrosive agents. It provides substantial protection against many kinds of refinery corrosion which, heretofore, have been accepted as being unavoidable.

For a prompt survey of your corrosion problems by a Tretolite Company refinery engineer, write or call the

TRETOLITE COMPANY
SAINT LOUIS 19, MISSOURI
LOS ANGELES 22, CALIFORNIA

CORROSION INHIBITING • DESALTING
DEHYDRATING • WATER DE-OILING
SCALE PREVENTING

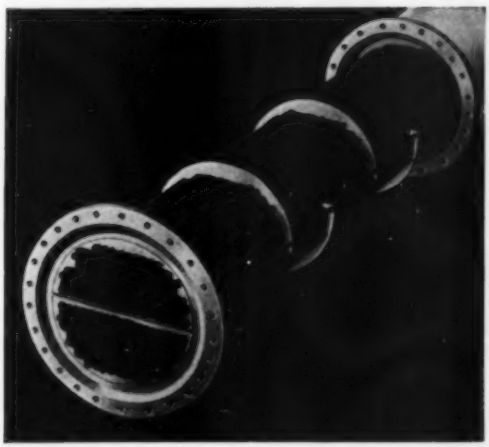
How to Cut Down Shutdowns

Anyone engaged in the refining industry, which works continuously around the clock, knows that shutdowns are expensive.

The one thing that will help reduce these shutdowns is more care exercised in the selection of materials that go to make up the equipment. Every part must function with dependability. And what part demands more dependability than the condenser tubes?

The condenser tubes that are recognized everywhere for their unquestioned dependability are Wolverine seamless, nonferrous tubes—the tubes that are quality controlled from ore to finished product.

These condenser tubes are available in any copper alloy that you may require to meet your particular conditions. Our engineers are always ready to consult with you on the most suitable alloy to use in your particular application.



WOLVERINE TUBE DIVISION
Calumet & Hecla Consolidated Copper Company
INCORPORATED
Manufacturers of seamless, nonferrous tubing
1431 CENTRAL AVENUE • DETROIT 9, MICHIGAN

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA
Sales Offices in Principal Cities

Export Department, 13 E. 40th St., New York 16, N.Y. AD No. C-3231

CHECK THESE 3 WAYS YOU CAN SAVE WITH THIS MULTI-PURPOSE INSTRUMENT

Here is the most sensible idea you've ever seen in a recorder or controller—an instrument you can change as your instrument needs change, that you can add to, subtract from, or whose functions you can increase or decrease at little or no expense.

✓ **Save money when you add new functions by adding only those new assemblies needed.**

✓ **Save time-delays by making changes on the job site without returning to factory.**

✓ **Save money on inventory. Parts are interchangeable, fit all Gotham Convertible recorders. You can service a whole group with a minimum stock of basic elements.**

What you can do with the Gotham Convertible

Depending on the chart size of the recorder (6", 9" or 12") you can have a 1-2-3 or 4 pen recorder with 14 pressure, temperature and time operation combinations or a recorder-controller with 38 possible pressure, temperature, and time combinations.

SELF-CONTAINED PORTABLE RECORDER

A portable recorder which has a carrying handle, legs and retaining holder for capillary and bulb. Built from Gotham standard elements, interchangeable with other Gotham instruments. 6", 9" and 12" chart sizes. Mercury, Vapor or Pressure Activated. Spring or electric chart drive. See Catalog 400.

RECORDING PSYCHROMETER

Incorporates the same highly accurate and responsive thermal systems and contains all other Gotham standard convertible features. Wet and dry bulb type. Motor-driven suction fan. 12" chart size. Catalog 400.

RECORDING HYGROMETER

A 2-pen recorder of the wet and dry bulb type. Mercury or Vapor Actuated. 9" and 12" chart sizes. Available with variety of wet and dry bulb assemblies depending on application. Catalog 400.

GOTHAM INSTRUMENTS

Keep everything under control with Gotham

GOTHAM INSTRUMENTS
Division of American Machine and Metals, Inc.
Dept. 6, 233 Broadway
New York 12, New York

Please send me a copy of your

- ☐ Catalog 100—Industrial Thermometers
- ☐ Catalog 200—Dial Type Thermometers
- ☐ Catalog 400—Recorders, Psychrometers, Hygrometers
- ☐ Catalog 500—Controllers
- ☐ Have your representative call. No obligation.

Name _____ Title _____

Company _____

Address _____

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ANOTHER **ERKOTE** APPLICATION OF MASTIC COATING

This sphere never gets "hot under the collar"

Butane storage tanks such as this 40,000 barrel capacity Hortonsphere have to maintain low inside temperatures under complete weather cycling or the contents will vaporize.

A single ½" coating of ERKOTE 3X Insulating Mastic reduces heat transfer and provides a permanent protective surface for this unusual structure.

ERKOTE 3X is readily applied by spray and adheres to almost any type of surface. It requires no mechanical means to hold it in place regardless of surface angle; it sheds water, and it is extremely resistant to chemicals and corrosive fumes.

ERKOTE Technical Coatings—both Mastics and Paints—are used by many industries such as utilities, textiles, chemicals, railroads, paper mills and oil refineries for weather proofing, insulating and protecting against corrosion.

We offer you impartial advice on your problems

Since we manufacture both mastics and paints for industrial protection we can supply the exact surface coating to satisfy your requirements. Our engineers will be glad to help you with our recommendations.

ERKOTE Products . . . your assurance of *undivided* responsibility

Because we develop and produce our own mastics and paints and furnish our own trained crews to apply and maintain ERKOTE products with our own special equipment we assume *full responsibility* for the quality of the materials and the workmanship.

Would you like to know more about ERKOTE Technical Coatings? We will be glad to send you a booklet describing the many uses for our products.

EARL PAINT CORPORATION
240 Genesee Street
UTICA, NEW YORK

ERKOTE PRODUCTS

Corrosion Resisting Mastics, Mica Mastics, Insulating Mastics, Vapor Seals, Troweling Mastics, Color Finishers, Industrial Paints and Varnishes.

ERKOTE TECHNICAL COATINGS

FOR USE WHERE PAINTS FAIL

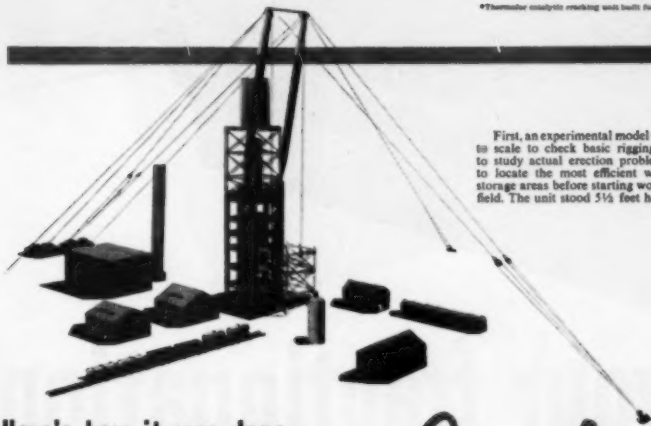
It took 60 years to save three months

on Socony's new cat-cracker*

The cat-cracker, the most important processing unit in a refinery today, is usually built from the ground up like a skyscraper—one or two floors at a time. But Fluor has developed a new time-saving technique of designing the component parts so that they can be fabricated on the ground simultaneously and lifted into place, thereby making more efficient use of manpower and equipment. Construction crews work in perfect coordination on a production-line basis to effect substantial savings in construction costs, but above all *in time!*

Fluor designed and constructed the catalytic cracking unit shown here for Socony-Vacuum at Augusta, Kansas. It stands 268 feet high, equivalent to a 22-story building. Nine months and 13 days after foundation was poured, it went on stream for 15,000 barrels a day, three months earlier than could be normally expected if built by conventional methods under similar circumstances. This airlift TCC unit processes about 1½ million barrels of oil in three months; that's why getting it into operation in the shortest possible time was an all-important objective.

*Thermofor catalytic cracking unit built for Socony-Vacuum Oil Company at their Augusta, Kansas refinery.

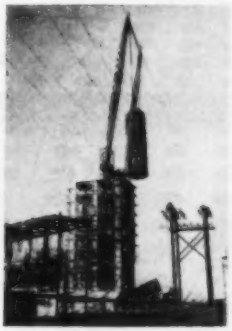


First, an experimental model was built to scale to check basic rigging design, to study actual erection problems, and to locate the most efficient work and storage areas before starting work in the field. The unit stood 5½ feet high.

October 26

Reinforced concrete was used to a height of 100 feet for fire protection. While the base was being poured (August 21, 1950), these concrete panels weighing 85 tons each were being cast on the ground slab.

Here's how it was done— from conception to *Completion*



December 22

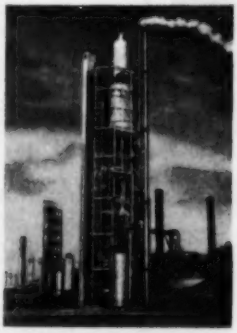
In spite of sub-zero weather, the building marathon continues. The Reactor weighing 100 tons is being hoisted 100 feet into the air. It took less than an hour to complete this operation. The cracking process takes place in this unit.

January 4

This steel section, assembled on the ground and weighing 110 tons, was lifted 160 feet and lowered into place over the Reactor. It supports the Hot Catalyst Bin. This is one of 28 major lifts varying in weight from 60 to 125 tons.

March 5

After the last steel section was set, the Separator Surge Drum (63 tons) is raised into place on top. This was the last lift to be made. Total height is now 268 feet, 22 stories high, and is one of the tallest structures in Kansas.



May 10

Operation testing completed and ready for start up, 9 months and 13 days after foundation was finished. This cat-cracker is capable of processing 630,000 gallons of oil every day. Fluor has four more similar units under way.

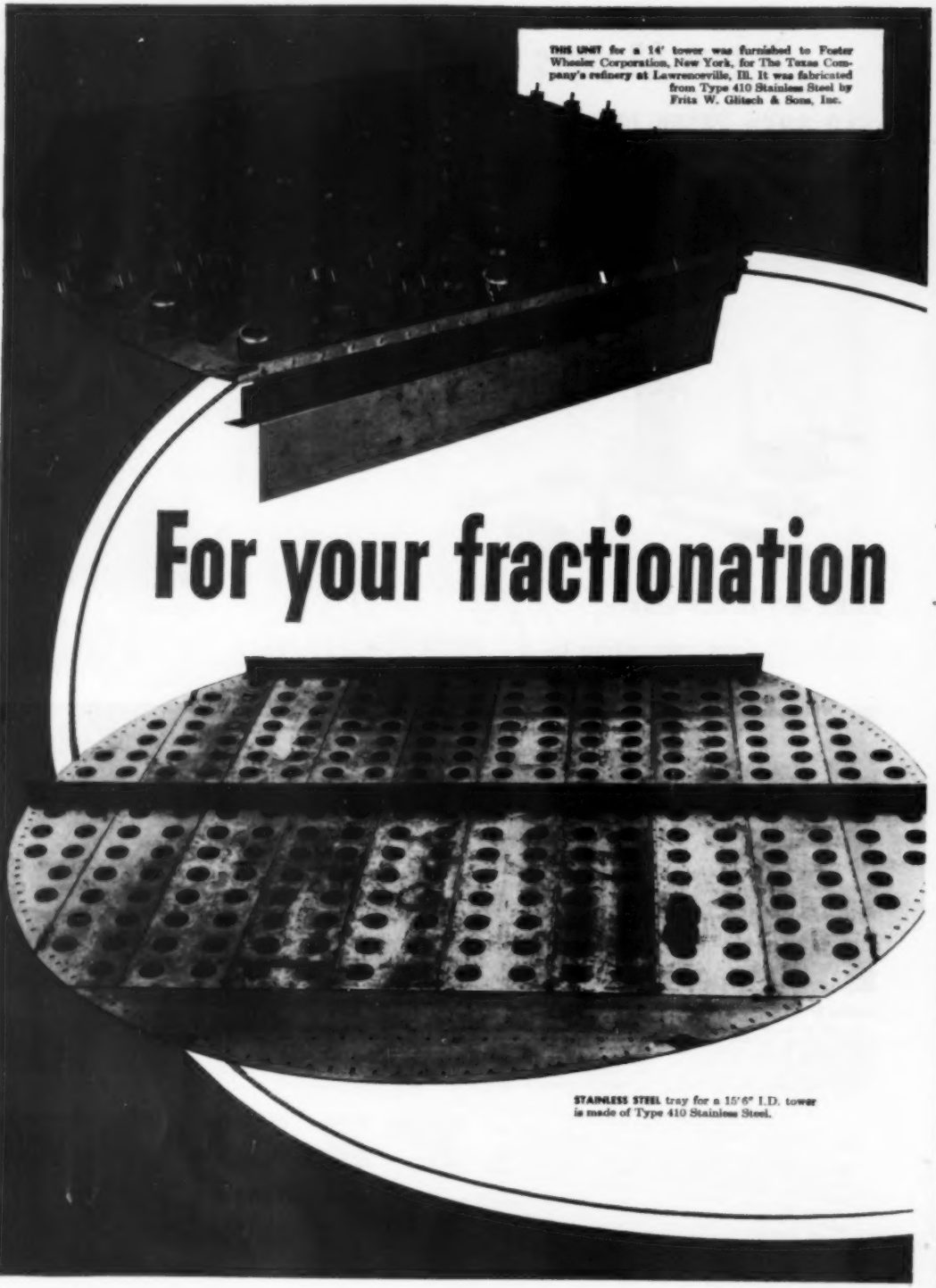
For 60 years Fluor has been building for industry and is among the leaders in plant construction for the oil, gasoline, chemical and power industries in and out of the continental United States. If time-saving is your concern, take time to contact your nearest Fluor district office for details. Write for Bulletin CC2521 describing Fluor activity in the construction of Fluid and Thermofor cat-crackers.

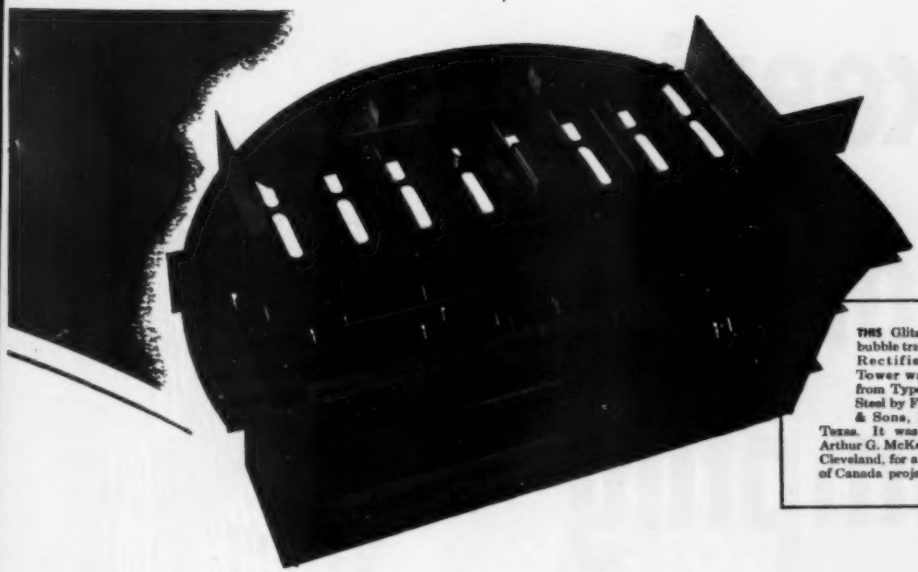
FLUOR

Engineers - Constructors - Manufacturers

THE FLUOR CORPORATION, LTD., 2500 S. ATLANTIC BLVD., LOS ANGELES 22, CALIF.
New York, Chicago, Pittsburgh, Tulsa, Houston, San Francisco

Represented in the Sterling areas by:
Head Wrightson Processes Ltd., Teesdale House, Baltic Street, London, E.C.1., England


THIS UNIT for a 14' tower was furnished to Foster Wheeler Corporation, New York, for The Texas Company's refinery at Lawrenceville, Ill. It was fabricated from Type 410 Stainless Steel by Frita W. Glitsch & Sons, Inc.
For your fractionation
STAINLESS STEEL tray for a 15'6" I.D. tower is made of Type 410 Stainless Steel.



THIS Glitsch truss-type bubble tray for a 6'6" I.D. Rectified Absorber Tower was fabricated from Type 410 Stainless Steel by Fritz W. Glitsch & Sons, Inc., Dallas, Texas. It was furnished to Arthur G. McKee & Company, Cleveland, for a Shell Oil Co. of Canada project.

tower "internals" take advantage of available U·S·S 12 Stainless Steel

(no CMP tickets needed)

USED in bubble caps, trays, weirs, risers, floors, trusses, major beams, uptakes and downcomers, U·S·S 12 (Type 410) Stainless Steel offers maximum corrosion resistance for your money. At the same time, use of this available straight-chromium grade helps conserve the supply of nickel-bearing Stainless Steels.

Type 410 Stainless Steel has a long history of satisfactory service in these types of applications. As long as ten years ago, more than 500 sets of bubble caps and trays fabricated from Type 410 were in use and giving highly satisfactory service.

One fabricator who has used Type 410 Stainless extensively since 1938 finds it has a life 6 to 7 times that of carbon steel under normal operating conditions.

This grade of Stainless Steel has excellent resistance to the corrosive conditions encountered in fractionation towers. And it resists the effect of temperatures encountered in this type of operation—as high as 1000°F.

Stainless Steel's dense, smooth surface prevents coking and fouling, thus permitting longer runs with less down time for cleaning. Its strength and toughness mean less breakage and less wasted tray area. Because of its high corrosion resistance and its formability, thinner sections can be used and one-piece bubble caps, risers, etc. can be made. Together, this makes possible longer life and lighter weight units.

U·S·S 12 Stainless Steel—a service-tested material—will give you unmatched performance in these internal parts. Specify it to your fabricator; he needs no CMP tickets for any form of this material.

UNITED STATES STEEL COMPANY, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

U·S·S STAINLESS STEEL

USS

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

3-383

UNITED STATES STEEL

keeping a tool joint "jumping"

for twice the usual service with Airco Hardfacing Alloys

Tool joint killers: Increased drilling depths — higher penetration rates—faster rotating speeds — these are the factors that add dollars to drilling and maintenance costs.

Unless — Airco Hardfacing Alloys are given the job of holding expenses to a minimum. For with these shock and abrasion-resistant alloys you may double your tool joint life—even under the toughest drilling conditions. And of extra importance: Not only is wear greatly reduced but correct box end diameters are maintained.

If you're being faced today with tool joint problems, there's an Airco representative near you who can help. Just write or phone your local office for the information you need.

AT THE FRONTIERS OF PROGRESS YOU'LL FIND

AN AIR REDUCTION PRODUCT

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DEALERS AND OFFICES IN PRINCIPAL CITIES

AIR REDUCTION MAGNOLIA COMPANY

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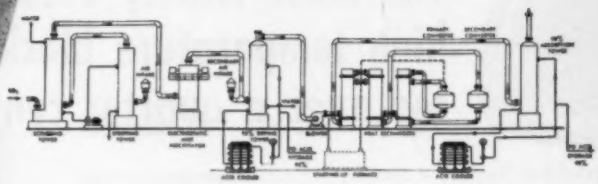
Southwestern Headquarters for Oxygen, Acetylene and Other Gases... Carbide... Gas Welding and Cutting Machines, Apparatus and Supplies... Arc Welders, Electrodes and Accessories

SO_2 up the stack....

...wastes a valuable source of H_2SO_4



You can produce much-needed sulfuric acid at a profit, if you have by-product sulfur dioxide in suitable quantity and strength from your chemical or smelting operations. The Chemico process, diagrammed above, or modified to suit specific conditions, provides a practical, efficient method for converting SO_2 into clean sulfuric acid. Chemico will design and construct the complete plant . . . deliver it in smooth-running operation on a performance-guaranteed basis. For specific recommendations, write us describing your problem fully.

This diagram shows how SO_2 gas is purified, dried, reheated and converted into H_2SO_4 of any desired strength.

CHEMICAL CONSTRUCTION CORPORATION

A UNIT OF AMERICAN CYANAMID COMPANY

488 MADISON AVENUE, NEW YORK 22, N. Y.

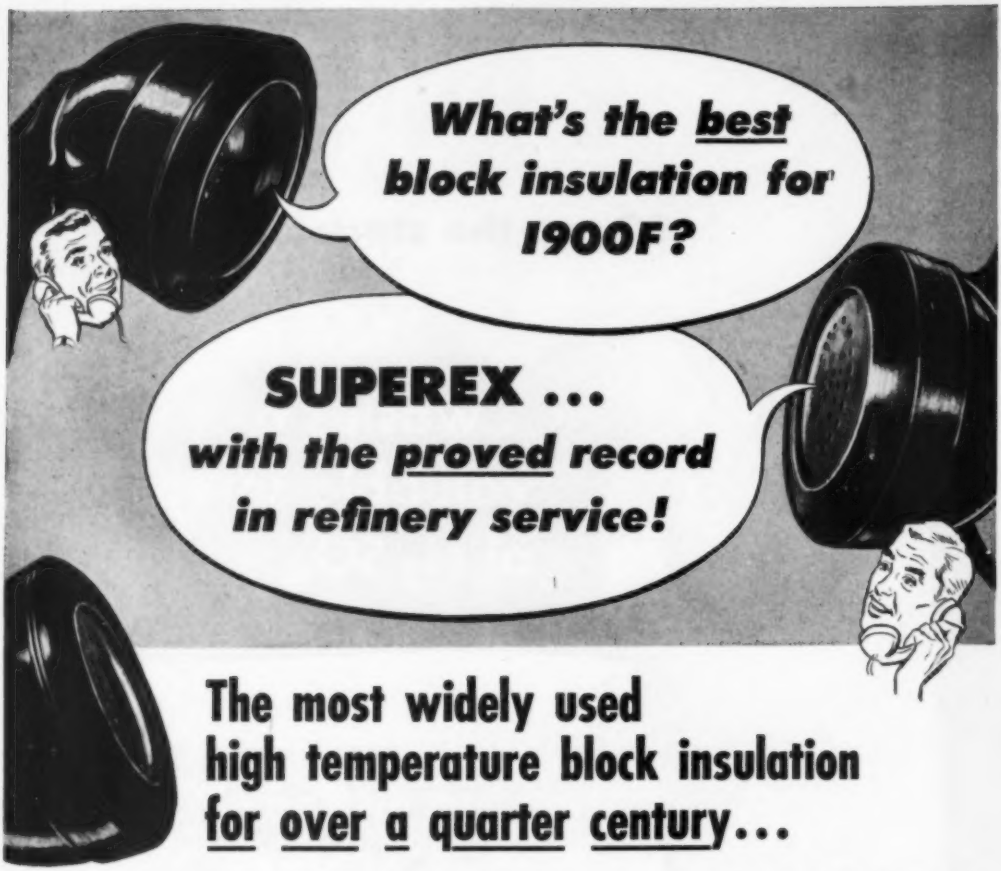
CABLES: CHEMICONST, NEW YORK

TECHNICAL REPRESENTATIVE IN EUROPE—CYANAMID PRODUCTS LTD., LONDON

TECHNICAL REPRESENTATIVE IN SOUTHERN AFRICA—SOUTH AFRICA CYANAMID (PTY) LTD., JOHANNESBURG

CHEMICO PROCESS CONSTRUCTION

Chemico plants are profitable investments



The most widely used high temperature block insulation for over a quarter century...

SUPEREX® high temperature block insulation has long been industry's No. 1 choice for service temperatures up to 1900F. It provides *major* economies . . . reduces fuel costs, cuts heat losses, keeps maintenance expense down, costs less to install and has long service life.

Made of specially selected and calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fiber, Superex will safely withstand temperatures up to 1900F with negligible shrinkage.

Superex has been used with outstanding success in all types of ovens, stationary and marine boilers, auxiliary power plant equipment, stills, reactor chambers, regenerators, high temperature mains, heaters, flues, stacks, and other types of high temperature equipment.

Superex has all these important advantages...

Low thermal conductivity—Exceptionally high heat resistance (1900F) combined with excellent insulating value.

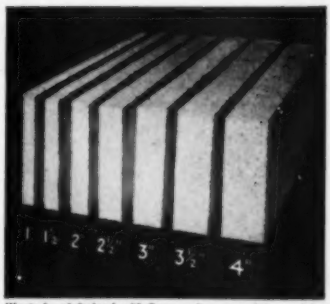
Light weight—Approximately 2 lb per sq ft per in. thickness.

Great physical strength—Approximately 6 tons pressure per sq ft are required to compress Superex ½ in.

Long, efficient service life—Superex maintains high insulating value indefinitely—will not disintegrate in the service for which it is recommended.

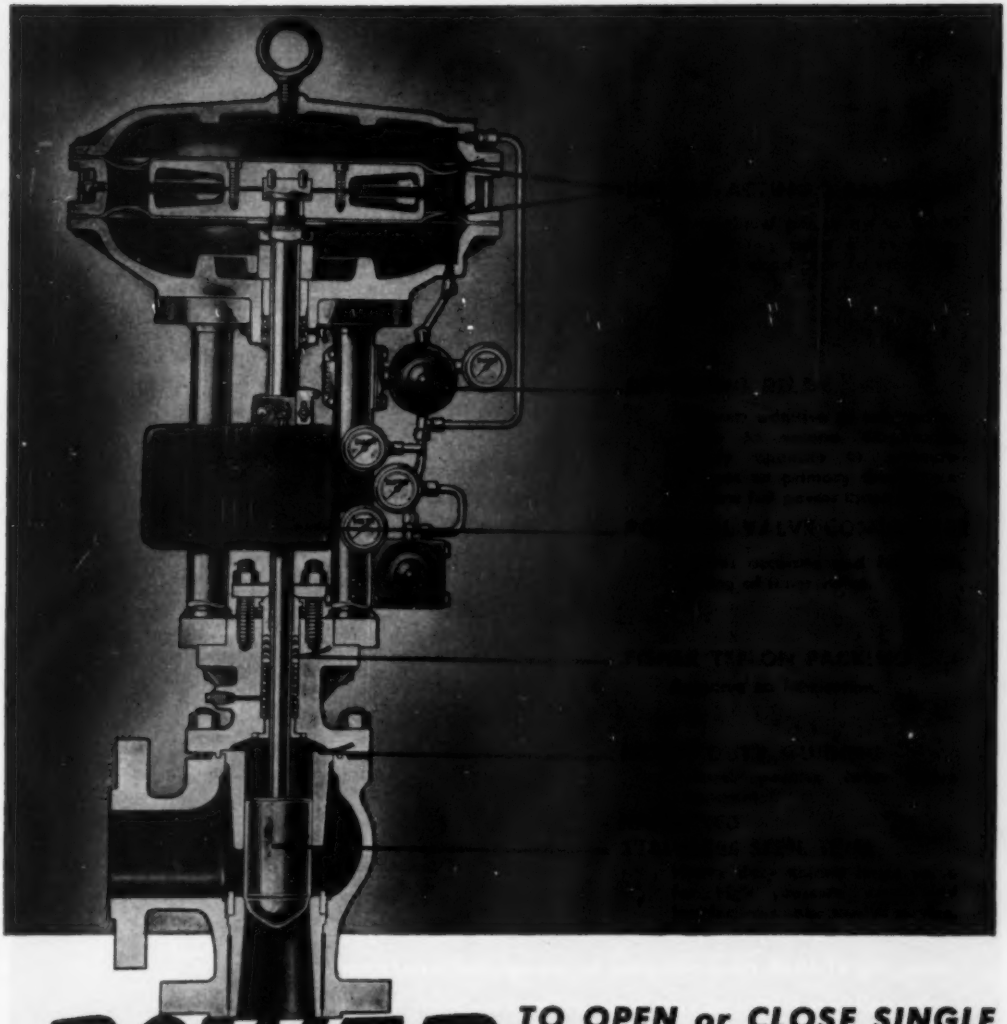
Fast, easy application—Superex may be cut with an ordinary knife or saw for fitting around openings or to irregular surfaces. Because of its light weight and convenient sizes, Superex assures fast and economical installations.

For complete information about Superex block insulation, write for Brochure IN-134A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.



Waste is minimized with Superex because of the variety of thicknesses available. Special shapes and intermediate thicknesses between those shown are also available.

Johns-Manville *first in* INSULATIONS



POWER

TO OPEN or CLOSE SINGLE SEATED VALVES UNDER HIGH PRESSURE DROP CONDITIONS

Fisher Type 5700-458 "AMT" pressure balanced diaphragm motor valve will actuate large single-seated valves for tight shut-off on high pressure drops. It features full pneumatic performance — no springs, no levers or weights. Double diaphragm avoids backlash effects probable with single diaphragm construction. Develops up to 5,000 lbs. stem thrust with 30 lbs. air supply. Designed for fast stroke action. Fully strokes inner valves in 13 seconds.

WRITE TODAY FOR BULLETIN B-5700

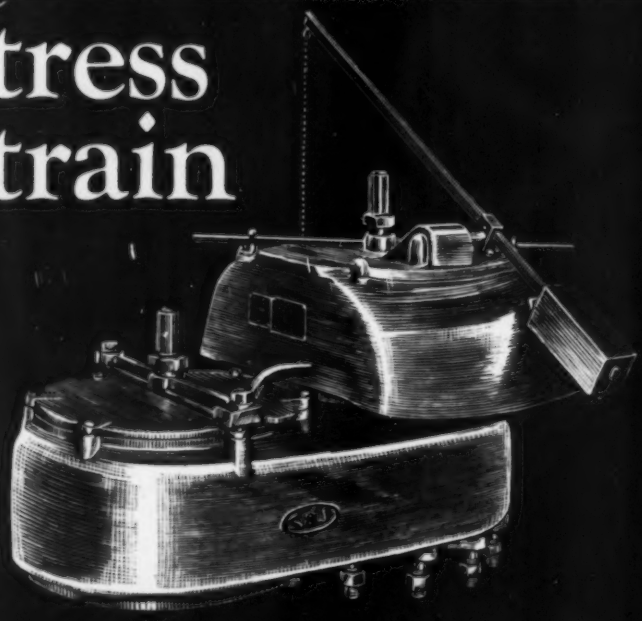
FISHER **AMT***

DIAPHRAGM MOTOR VALVES FOR HEAVY DUTY SERVICE

* **AMT** "Answer Me Twice". In action, pressure added to one diaphragm, subtracted from other.

FISHER GOVERNOR COMPANY **Marshalltown, Iowa**

NO stress
NO strain



ABOVE GROUND petroleum storage and transfer tanks never suffer from stresses, aches or strains when equipped with the new Shand & Jurs poppet type breather valve. It provides tremendously increased flow capacities within the range of normal pressure settings and overpressure allowances, and this S&J poppet type breather valve will deliver the acme of performance under all weather and operating conditions.

Check these quality features that make the S&J poppet type breather valve, Fig. ST-6949, the prescription for storage and transfer tank health: valve pallets automatically drain all condensation away from their seats; molded thermosetting phenolic pallets and stainless steel pallet guides offer maximum resistance to corrosion; completely screened valve openings keep windblown particles, insects, rain, sleet and snow from hindering operation; quick removable pressure and vacuum hoods for easy inspection or what little maintenance is necessary.

S&J

Shand and Jurs Co. 8TH AND CARLTON STREETS · BERKELEY · CALIFORNIA

NEW YORK 295 Madison Ave. · CHICAGO 10409 S. Western Ave. · HOUSTON 827 M & M Bldg. · TULSA 310 Thompson Bldg. · LOS ANGELES 714 W. Olympic Blvd. · SEATTLE 3600 Western Ave.

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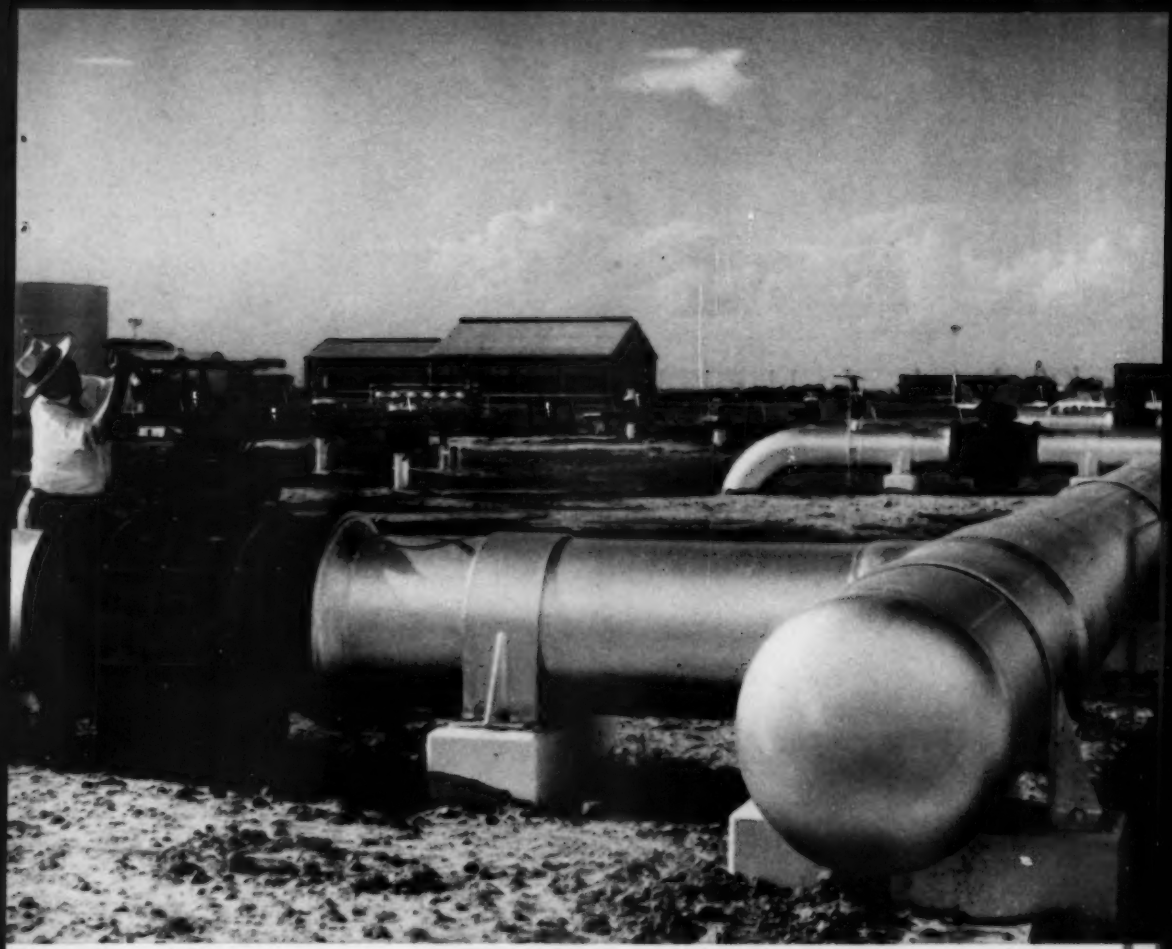


WHEN YOU

Standardize on Nordstrom Valves You Standardize on Dependability

Whatever the service, whatever the size of the line, write Nordstrom valves into your standards. That way, you can make your first valve installation in any spot a permanent one.

Rockwell Built
Another Rockwell Product **Nordstrom Valves**
LUBRICANT SEALED TO KEEP UPKEEP DOWN

A $150 Valve with a $5,000,000 Job

Somewhere in almost every plant, somewhere in almost every line of flow, there is a key valve—a valve that *must* operate in an emergency.

Often one small valve that costs only a few dollars protects plant investment running into millions and human life beyond price.

Take the case of the valve shown here. This is the control valve which actuates the cylinder controlled Nordstrom valves in case of emergency, and divorces the compressor station from the main line. It closes the inlet and outlet of the station and opens the main line valve.

Most often a key valve like this will be a Nordstrom. Because Nordstroms perform so well in key spots . . . because any piping system is only as good as the valves that control it, naturally Nordstrom valves have been specified for thousands of petroleum, gas, chemical and general industrial services.

The Nordstrom record of dependability and low cost is the best recommendation you could ask. Rockwell Manufacturing Company, 400 N. Lexington Ave., Pittsburgh 8, Pa.

Rockwell Another Rockwell Product **Built**

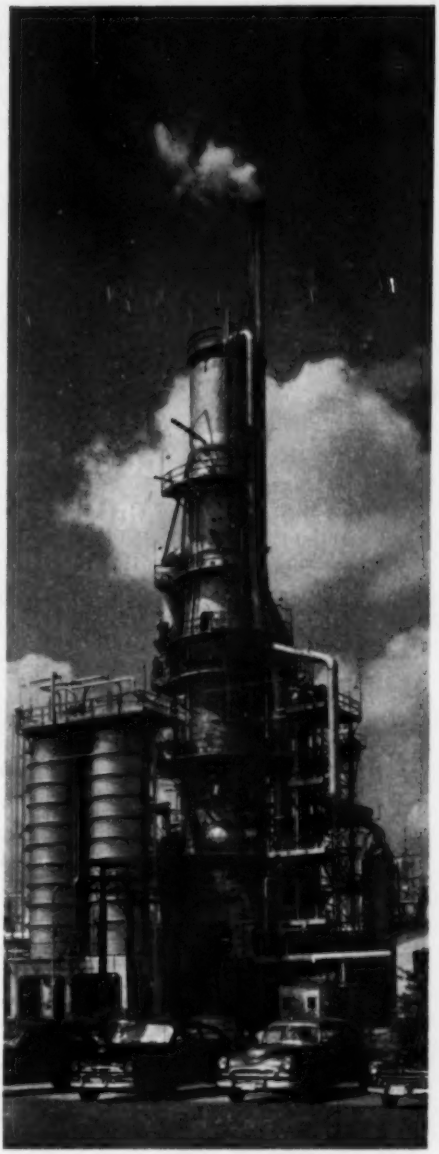
Nordstrom Valves

LUBRICANT SEALED TO KEEP UPKEEP DOWN

Rock Island Refinery

MODERNIZATION brings GREATER YIELDS from Crudes

Left: Erection view of the fluid catalytic cracker at the Rock Island Refining Corporation's Zionsville, Indiana refinery.



When Rock Island Refining Corporation modernized their Zionsville, Indiana refinery, they naturally installed efficient, high capacity equipment . . . equipment that would help them produce the highest practical yields from every barrel of crude oil.

The new U.O.P. fluid catalytic cracking unit shown at the right was chosen because it embodies many of the most recent operating techniques. It has a rated capacity of 5,000 bbls. per day, and replaces a thermal cracker-reformer which was converted to crude distillation service. Fabrication and partial erection of many structures comprising the fluid catalytic cracking unit—the 8-ft. by 79-ft. 6-in. crude unit fractionator, the 6-ft. 6-in. by 85-ft. 8-in. main cat cracker fractionator, two 11-ft. 6-in. by 40-ft. catalyst hoppers, and the reactor generator—was done by the Chicago Bridge and Iron Company. In addition, we also supplied the refinery with two processing towers, a group of cone roof tanks, a Horton Vaporsphere, a debutanizer relief drum, and a water settling tank.

Our ability to fabricate and erect almost every type of storage tank or refinery tower for the oil and gas industry is proved by thousands of installations throughout the world. Write our nearest office the next time you require these special types of steel structures.

CHICAGO BRIDGE & IRON COMPANY

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Cleveland 15 ..... 2234 Guildhall Building
Detroit 26 ..... 1520 Lafayette Building
Havana ..... 402 Abreu Building
Houston 2 ..... 2126 C & I Life Building
Los Angeles 17 ..... 1534 General Petroleum Building
New York 6 ..... 3302—165 Broadway Building
Philadelphia 3 ..... 1608—1700 Walnut Street Building
San Francisco 4 ..... 1551—200 Bush Street
Seattle 1 ..... 1331 Henry Building
Tulsa 3 ..... 1626 Hunt Building
Washington 6, D. C. ..... 1128 Cafritz Building

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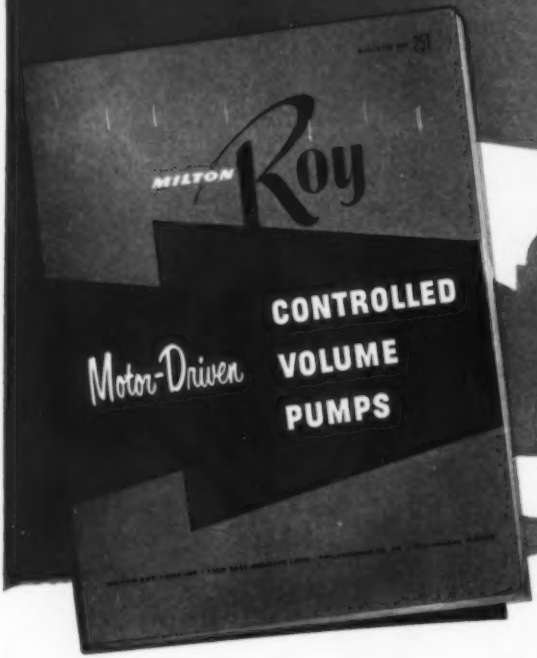
Motor-Driven CONTROLLED VOLUME PUMPS



Complete Information In These Pages

What *are* Milton Roy Motor-Driven Controlled Volume Pumps? What materials do they pump? How and where are they used? What different designs and models are available?

The answers to these questions and many more can be found in Bulletin No. 251. This illustrated, 24-page, 2-color bulletin is full of important details. Here is a preview of some of the subjects which are discussed:

- a description of various Milton Roy Motor-Driven Controlled Volume Pumps—the Simplex, Duplex, Constametric, "Titronic," and "miniPump."
- an explanation of the exclusive Milton Roy Liquid End Step-Valve design. This information is useful because it describes the "how" and "why" of this unique non-clogging, self-cleaning liquid end.
- a description of pump capacity regulation by *plunger stroke* adjustment, including screw adjustment, micro adjustment, motorized micro adjustment.
- details on pump capacity regulation by *plunger speed* adjustment, including speedranger adjustment, "Thymotrol" adjustment, Link Belt P.I.V. adjustment.
- data on where Milton Roy Motor-Driven Controlled Volume Pumps can be used.
- capacity-pressure selection tables are included.

If your operations call for pumping liquids in accurately measured volume in amounts as low as 3 milliliters per hour or as high as 50 gallons per minute, we're sure Bulletin No. 251 will be of value to you. For your free copy, write the Milton Roy representative listed in your local classified telephone directory. Or, write directly to us.

Manufacturing Engineers

WITH THE EXCLUSIVE STEP-VALVE DESIGN

MILTON Roy COMPANY

1315 EAST MERMAID LANE, PHILADELPHIA 18, PA.

CONTROLLED VOLUME PUMPS AND AUTOMATIC CHEMICAL FEED SYSTEMS

traps help uncover hidden steam treasure

The facts are these:

A large southern chemical company about a year ago was up to capacity on their boilers. New process units were being added, requiring more steam—a new boiler seemed inevitable.

About that time they began replacing their old-type traps and bleed-off valves with Yarway Impulse Steam Traps and Strainers. Today, even with the new process units added, their daily steam consumption is nearly 100,000 lbs less than a year ago—the superintendent gives Yarway Impulse Traps credit for the saving.

Yarway Impulse Traps are *designed* to insure sending the most premium B.T.U.'s at top temperature into your product or process . . . *to get equipment hotter sooner and keep it hot!*

Yarway's have 11 other advantages, too—such as *small size, low maintenance, low cost, and availability* from over 200 Industrial Distributors. Write for Bulletin T-1740. Or for steam trap advice, call on your nearby Yarway service engineer.

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.

the steam trap designed with more production in mind

PSC REFINERY TUBES
in *ANY SIZE*, any alloy

PSC tubes are furnished in any diameter up to 60"; likewise in any alloy whatsoever. This unlimited range of PSC welded alloy tubes accounts for their wide application in meeting the unlimited variety of heat, corrosion and oxidation conditions experienced in refineries.

ANY SHAPE or DIAMETER UP TO 60"

PSC welded alloy tubes are in use in every important refining area. They are furnished for catalytic, polymerization and other processes, in any of the complete range of stainless and heat-resisting steels. Tubes for heat exchangers, pyrometer protection, acid resistance, etc. In any wall thickness up to 3/8"; temperatures to 2200°; butt-welded to make any required length. We also offer a wealth of experience in the precision fabrication of tubing assemblies to your designs. Write as to your needs, or for address of your PSC representative.

WALL THICKNESS	MIN'M O. D.
1/16"	.840"
1/8"	1.050"
3/16"	1.900"
1/4"	2.875"
5/16"	8.625"
3/8"	10.750"

PSC EQUIPMENT IS "ALLOY RIGHT"

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

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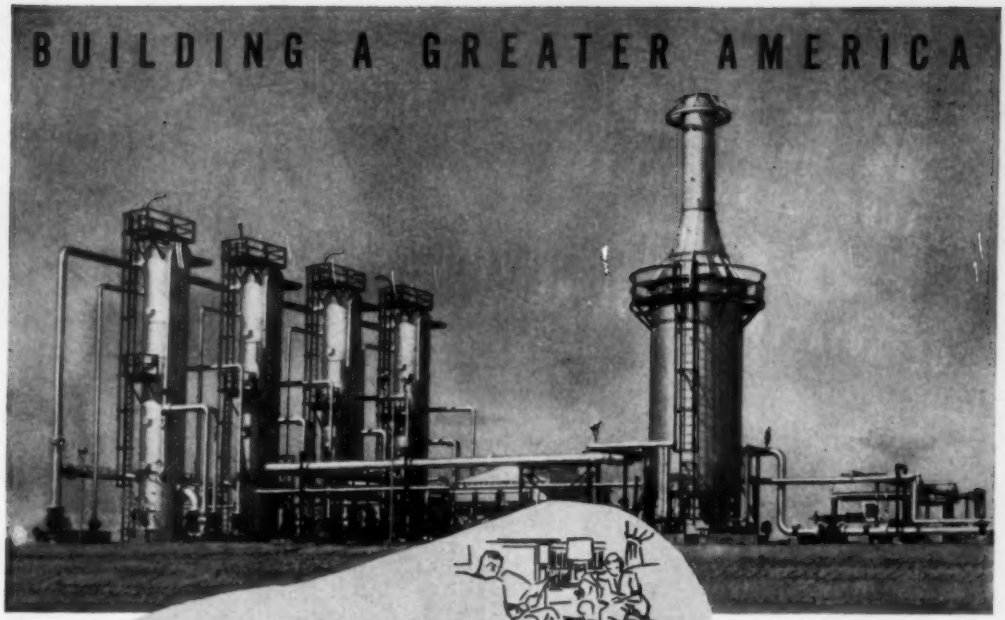
BUILDING A GREATER AMERICA



Built at Sun Ship, on the Delaware, these dehydrating towers now serve Western homes and industries.

Across the wide Missouri

Pioneers in prairie schooners blazed a courageous trail "across the wide Missouri . . ." and across the entire continent . . . in their search for new opportunity.

The industrial services of modern America have followed in that trail. Thriving farms, towns and cities mark sites where pioneers found only hardship . . . because American industry is truly "All-American."

Today, *all* America shares the benefits of *all* of America's progress . . . because great companies develop and distribute the advantages latent in our natural resources . . . and because great industries like Sun Ship can build and deliver, anywhere in the world, the gigantic equipment needed to convert petroleum and various chemicals into light, heat, power and the other productive forces which serve mankind's comfort and progress.

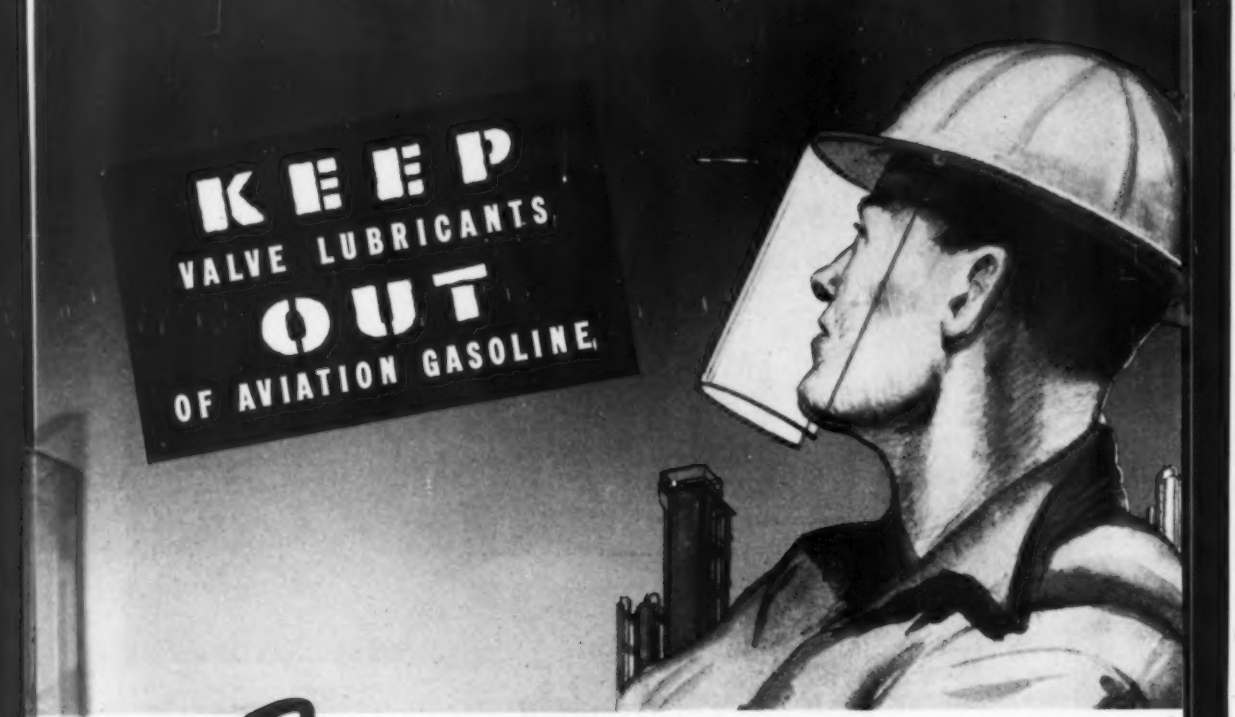
Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.

25 BROADWAY • NEW YORK CITY



Cameron NON-LUBRICATED LIFT-PLUG VALVES

Plug Actuator which lifts, turns and seats plugs in ¼ turn of operating lever.
Separate, renewable seat . . . easily changed without removing valve from line.

The costly refining and blending processes required to produce aviation gasoline may be partially nullified by greases which wash out of lubricated valves and stop cocks. This source of product contamination may be effectively eliminated through the use of Cameron NON-LUBRICATED Lift-Plug Valves. These remarkable valves operate easily and effect a positive closure without the aid of lubricants.

Aviation gasoline is one of a number of difficult industrial services where these remarkable valves have turned in an outstanding performance. They may hold the answer to **your** valve problems, too. Send today for literature.

CAMERON IRON WORKS, INC.

P. O. BOX 1212 • HOUSTON, TEXAS

Export Office, 74 Trinity Place, New York, N. Y. • Sterling Area: British Oil Field Equipment Co., Ltd., Duke's Court, St. James's, London S.W.1, England. • California: Cameron Iron Works of California, Box 267, Long Beach • Canada: Cameron Iron Works of Canada, Ltd., 9860-68th Ave., Suite 5, Edmonton, Alberta.

SELLING THROUGH SUPPLY STORES

Fullers Earth
Activated Bauxites

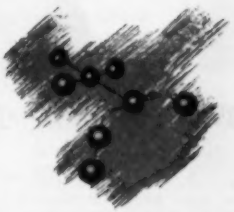
...two reliable names along the path of petroleum processing

WHAT DO YOU WANT TO PURIFY?

There's an Attapulgus or Porocel adsorbent to fit your process technique for removing odors, colors, tastes, moisture, acids, sulfur, fluorides and unsaturates from process liquids or gases. Materials treated in principal applications are: motor oils and other lubricating, specialty, and technical oils; petrolatums and waxes; aviation and motor gasoline stocks; kerosene; diesel and heating oils.

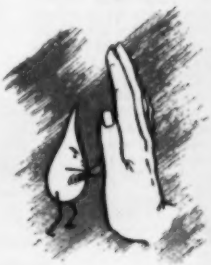
DO YOU HAVE CATALYST OR CATALYST CARRIER NEEDS?

Attapulgus or Porocel sorptive minerals are recognized standards in desulfurization, reforming and isomerization systems—catalytic removal of unsaturates—conversion of sulfides to elemental sulfur—fluid catalyst applications—as catalyst carrier in copper sweetening processes.



WHAT DO YOU WANT TO DRY?

We offer a wide range of reliable, thoroughly proved desiccants for drying air, hydrogen, carbon dioxide, hydrocarbon liquids and gases.



SPECIAL GRADES?

Mine and plant facilities permit prompt and economical production of grades meeting individual customer specifications. Our laboratories and technical staffs welcome the opportunity of assisting in research, development, design and operating problems. Your inquiries are invited.

ATTAPULGUS CLAY COMPANY *Fullers Earth* · **POROCEL** CORPORATION *Activated Bauxites*

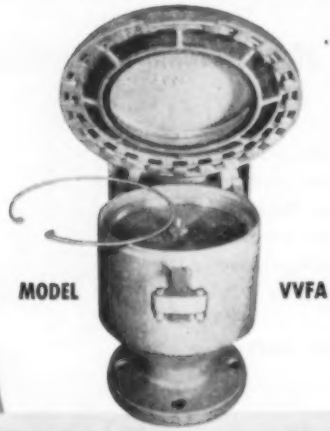
Dept. W, 210 West Washington Square, Philadelphia 5, Pa.

Positive Pressure Relief!

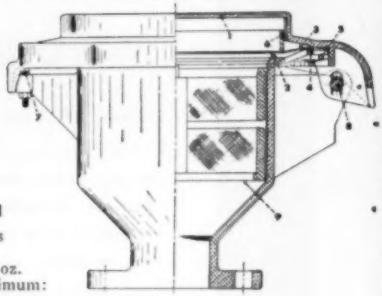
Efficient Fire Protection!

Lower Maintenance Costs!

with the BS&B COMBINATION VENT VALVE FLAME ARRESTER



The BS&B Model VVFA is a compact valve assembly that gives you many advantages. Its patented cantilever type arrangement of a synthetic rubber gasket eliminates metal-to-metal seating and provides a tight seal that increases in tightness until the pressure rises to the dead weight setting of the bonnet, thus assuring continued positive reseating. This gives you high vapor conservation and greater economy in operation. The arrester bank is housed in the valve body. Snuffing action is automatic. The arrester bank can be removed for cleaning or replacement without taking the valve out of service since the valve bonnet does not have to be removed. The cantilever type gasket can also be easily removed from the bonnet.



MATERIAL SPECIFICATIONS

Bonnet: cast aluminum
Body: cast iron
Retaining ring: cast aluminum
Vacuum ring: steel
Plug: synthetic rubber
Arrester bank: rolled corrugated aluminum
Flange: 125# A.S.A. standard

Sizes: 2, 3, 4 and 6-inch sizes available
Vacuum Setting: 0.5 oz. to 2 oz.
Pressure Setting: 0.5 oz. minimum: 16 oz. maximum all sizes

Note: Available in other materials of construction on special order.

BS&B Vent Valve—Model VVH

Contains all features of Model VVFA with exception of arrester bank. Can be used as a secondary relief valve with higher setting. Also as primary relief valve on non-flammable materials. The larger sizes of Model VVH can be used as a manway, thus saving an additional tank opening. Material specifications are the same as Model VVFA.

OPERATION DATA — MODEL VVFA Valve seat (2) is sealed by rubber gasket (3), vacuum ring (6) and internal pressure. As internal pressure approaches valve setting, patented cantilever type plug is disengaged from valve seat and bonnet (1) rises. Under vacuum conditions, atmospheric pressure is imposed to underneath side of plug. This permits "inbreathing" when pressure approaches 0.5 oz. setting of vaccum ring. A web-type support (4) holds plug in place. The valve also includes retaining ring spring (5), bumper spring (7), hinge (8) and arrester bank (9).

Ask Your Tank Manufacturer for BS&B Vent Valves on Your Equipment! To get greater economy of operation, ask to have the BS&B Combination Vent Valve-Flame Arrester installed on your equipment. Our engineers will work with your fabricators to meet your particular requirements.

ENGINEERING STUDY OF YOUR REQUIREMENTS
You are not obligated in any way when a BS&B engineer makes an analysis of your properties. Perhaps his recommendations will show you how to get more efficient, economical, safe operation.

NOW AVAILABLE Bulletin No. 601, which gives complete information on this equipment. **Write for your copy today.**

SAFETY BS&B HEADS

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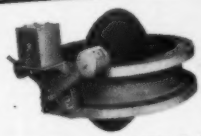
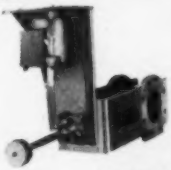
R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •

WATER SERVICE—No. 825—36-inch 125-pound cast iron valve equipped with 18—8 shafts, bronze bushings and rubber seat for 85-pound drip tight shut-off.

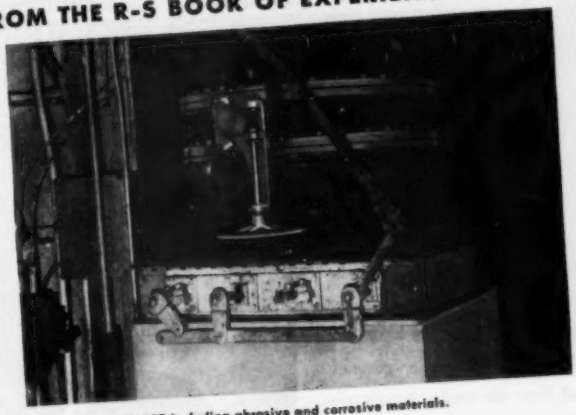


EMERGENCY OIL SERVICE—No. 628—solenoid trip valve. Should the solenoid function, the latch is tripped which causes the counter-weight to open or close the valve by gravity. Available in any metal or alloy and in various sizes for emergency shut-off or vent for air, gas, steam, oil, and water.



700° F. EXHAUST GAS SERVICE—No. 826—6-inch 125-pound R-S "H" metal valve used on small turbine generator. Equipped with 18—8 shafts, hastelloy bushings, finned lubricated stuffing box and solenoid trip mechanism.

STEAM SERVICE—No. 677—1500-pound welding end steel valve for superheated steam—A. S. M. E. Standards.



SEMI-SOLID SERVICE including abrasive and corrosive materials.

R-S VALVES

Control and Shut Off Practically Any Material

The beveled vane seats firmly at a 12½° angle and is closed from a fully open position through 77½° of arc by either manual or automatic operation. A metal-to-metal seat gives satisfactory commercial shut-off. When required, Monel or stainless steel can be welded to the vane periphery and a babbitted seat used in the valve body. Drip tight or bubble tight closure can be obtained with a rubber seat.

Power controlled prime movers delivering the necessary foot pounds of torque open or close these self-cleaning valves at any desired speed from one second to eight minutes according to requirements. Pressures range from 2 to 2500 psig and temperatures from minus 300° F. to plus 2000° F.

Such simplicity of design, adaptability and operating ease are the reasons why R-S Valves can be installed to control and shut off the volume and pressure of any material that flows or is forced through a pipe.

Obtain full details from your R-S representative.

R-S PRODUCTS CORPORATION

4600 Germantown Avenue, Philadelphia 44, Pa.

An S. Morgan Smith Company Subsidiary

DISTRICT OFFICES IN PRINCIPAL CITIES

LOW RESISTANCE to FLOW

Minimum resistance to flow . . . that is the feature of Midwest Welding Fittings we call to your attention with this photographic fantasy. Other superior qualities that result from our unique manufacturing methods are dimensional accuracy and uniformity . . . true circular cross-section, controlled wall thickness, and accurate radius, included arc and tangents. The consequent benefits are a saving in welding time and a better piping system.

MIDWEST "LONG TANGENT"

Same radius as ASA but tangent equal to 25% of nominal pipe size on each end. Saves pipe, layout and welding time. Costs no more than ASA. Sizes to 24".

ASA STANDARD

Dimensions conform to applicable size range of American Standard for Butt-Welding Fittings, ASA B16.9. Tolerances much less than allowable. Sizes to 26".

SHORT RADIUS

Recommended where space limitations do not permit use of "Long Tangent" or ASA Elbows. Sizes to 30".

MIDWEST REDUCING

Takes the place of a straight size elbow and a reducer. Eliminates one weld, reduces pressure drop, easier to insulate. Sizes to 12", reductions to half size.

4501

MIDWEST

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In the critical Cigar Conditioning Room of D. W. G. Cigar Corporation, Lima, O. **(home of such famous cigars as B. G. DUN, EL VERSO, and SAN FELICE)**, walls are ⅛" "Century" APAC. This asbestos-cement structural board is also used in the Cigar Machine Room and Tobacco Conditioning Tunnel.

"These walls of 'Century' APAC are an added safeguard where temperature and humidity must be accurately controlled,"

says J. P. Weller, Master Mechanic—

No nurse in an infants' ward ever guarded her charges more jealously than D. W. G. Cigar Corporation watches over the thousands of quality cigars they turn out every day.

So when J. P. Weller, D. W. G.'s Master Mechanic, chooses "Century" APAC for the walls of the important Cigar Conditioning Room, you can take his word that APAC is an ideal material where temperature and humidity are accurately controlled.

And because APAC is made of mineral asbestos and portland cement, you know fire can't burn it . . . water can't soak it and termites can't eat it.

You'll find this asbestos-cement structural board gives you as low a first cost and maintenance expense (*never* needs painting!) as any comparable material you can use for interior or exterior walls . . . ceilings . . . partitions . . . and linings.

It goes on fast, too—big sheets (standard 4′ x 8′) can be cut or drilled and fastened easily with screws or ring-fettered nails. Write us for details about "Century" APAC . . . and name of your nearest distributor.

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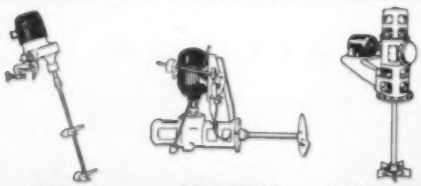

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- ☐ B-101 Condensed Catalog showing complete line
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API Refining Issue

ONE OF THE most outstanding technical programs on petroleum refining has just ended at the 17th mid-year meeting of the Division of Refining of the American Petroleum Institute in San Francisco, May 12-15.

Ten group technical sessions and an open dinner meeting were included on the four-day program. Among the subjects covered were analytical research, corrosion, industrial communications, automotive fuels, production and recovery of aromatics, and atmospheric pollution.

It is the feeling of the editors that the papers presented at this meeting have set a new high in technical calibre. Therefore we have designated this the API Refining Issue of PETROLEUM REFINER, herein publishing a selection from the papers presented at the meeting. Although it was our desire to publish the "cream of the crop," the actual selection of the limited number which space allows was exceedingly difficult because there were so many we wished to include.

Starting on page 97 appears six of the API papers, including three on the production and purification of aromatics, two on catalytic reforming, and one on corrosion. As a service to our readers, all but the first are published in their entirety.

Here's the Challenge

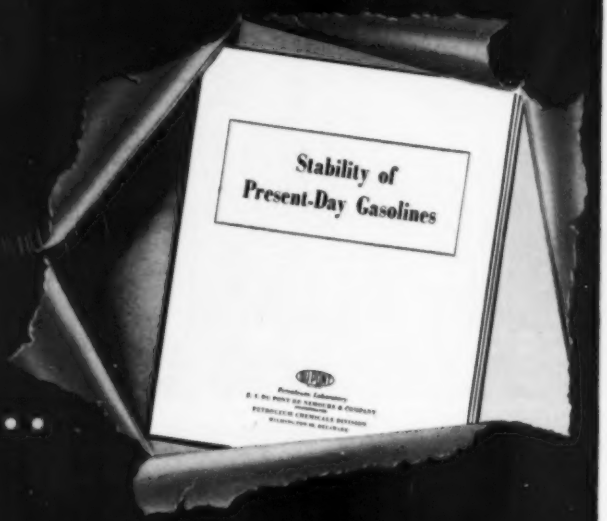
SPEAKING ON industry's most serious problem today, John S. Coleman, president, Burroughs Adding Machine Company, defined the problem of labor-management relations and threw this challenge to members of the Western Petroleum Refiners Association in its annual meeting at San Antonio:

"The development of mass production has given us the benefit of greatly increased output. Upon this new system of organization is built the American standard of living. The assembly line, the conveyor belt, the typing pool or a large accounting machine installation —all are alike in substance. They are all means of organizing large numbers of people in a common task. But it is not clear that mass production makes it difficult for the individual to see what that common task is? With the displacement of the hand tool by the assembly line, work has, in wide areas become strictly repetitive, initiative has been eliminated, and the significance of the job lost. The musician in an orchestra shares with the conductor an understanding of the whole symphony. But the man at the screw machine is often too far away to see unaided the planning and purpose which makes his job important to the organization.

"Insofar as industry exists for man and not man for industry, it must satisfy to a reasonable extent his fundamental needs. After what I have said about the nature of work, we can all agree that it is immensely difficult to provide the conditions for individual satisfaction. But that is the more reason why we should give it our close attention. Frustration and boredom are dangerous states of mind. On the surface listless and inert, these attitudes conceal emotional stresses that are the source of riot and violence. And they are, let me add, more widespread than we might care to admit. If then our society is to enjoy stability and in any real sense, freedom, the individual must find significance at the desk or the bench. He must find meaning in the organization of which he is a part. And no state with universal education and suffrage can expect him to tolerate a system which denies it."

Top-of-Page Photo—Engineer opens a valve in North Cowden, Texas, gasoline plant of Stanolind Oil and Gas Company

DU PONT OFFERS NEW DATA . . . ON THE DETERMINATION OF GASOLINE STORAGE STABILITY



DO ACCELERATED TESTS accurately measure the stability of modern catalytic-cracked gasolines when subjected to long-time storage?

There has been a growing feeling among refiners that induction period tests do not give as satisfactory results when applied to present-day gasolines as they did with earlier fuels. To evaluate the significance of accelerated tests, the Du Pont Petroleum Laboratory recently made a comprehensive study of the problem.

THE RESULTS of this work indicate that tests conducted at different temperatures do not necessarily correlate with each other. This lack of correlation appears to be due to differences in temperature sensitivity of the gasolines tested. But it is possible to develop a correlation for a specific stock provided the types of additives are not changed.

The tests also indicate that Du Pont Metal Deactivator provides much greater storage stability than is predicted from accelerated tests . . . and that the relative effectiveness of gasoline antioxidants in storage cannot be accurately predicted by these tests.

COMPLETE DATA from the Petroleum Laboratory's tests are available to refiners in a paper entitled "Stability of Present-Day Gasolines." For your copy, contact the nearest Du Pont Petroleum Chemicals Division district office.

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Supplies and The Strike

WITH THE NATION just entering the heavy gasoline consumption season, the refining industry had on hand the greatest amount of gasoline it had ever accumulated. That was indeed fortunate, for coincident with the motoring season's advent came shutdown of from 40 to 50 percent of the nation's refining capacity, and if the shutdown should prove to be prolonged those supplies will be sorely needed.

Before labor difficulties beset a large part of the U. S. refining industry the refined product supply picture was not altogether a happy one. While gasoline stocks had been pushed to all-time peaks, supplies of the fuel oils were not too far out in front of inventories of a year earlier. And current stocks were the leavings from the comparatively mild weather of last winter. Some increase in fuel oil demand is expected and with a severe winter the need would be considerably higher.

It was believed that if increased requirements of next winter are to be met, refiners will have to manufacture substantially larger quantities of heating oils in the next six months than ever before. That, of course, would call for stepped-up refining rates and readjustment of product yields. Processing more crude would also result in increased output of gasoline, and supplies of that product were not showing signs of shortness, in fact, there was some danger of their becoming excessive.

That was somewhat the pre-strike picture. Now it appears that the gasoline supply situation will certainly be changed by the curtailment of refining operations. A short lay-off would knock off the top of gasoline stocks and not cause serious damage unless the strike becomes drawn out, but outlook is not so bright for the fuel oils. Because, even a short lay-off means just that much loss to fuel oil supplies that were, even under more normal circumstances, probably going to see touch-and-go conditions.

More TEL Available

PETROLEUM refiners will be permitted to use 7 percent more automotive tetraethyl lead fluid in the 12 months which began March 1 than their authorized consumption during the previous 12 months. Relaxation of the restrictions on use of TEL was accomplished through amendment and extension for another year of Petroleum Administration for Defense Order No. 1 which would have expired at the end of February.

In computing the permitted 7 percent increase Deputy Petroleum Administrator Bruce K. Brown said the 1951 allocations under the restrictive order will be considered as the base and to this will be added all hardship grants made during the period of March 1, 1951, to February 29, 1952. These hardship grants were readjustments permitted in cases where refineries had been shut down during part of 1950, where motor gasoline production had to be abnormally increased, or where for some reason the base period use of TEL did not fairly reflect a refiner's need for the fluid.

Excluded from 1951 authorized use for determining the base allocation for the current 12 month period will be special grants made by PAD for extraordinary demands that are not expected to occur again, such as the grants made some refiners for production of military automotive gasoline.

The relaxed order was made possible by the increased supplies of metallic lead and other raw materials used in manufacture of TEL which made possible a boost in output of the fluid. PAD Order No. 1 was originally issued to conserve TEL and to help build a reserve supply against possible emergencies. It restricted refiners who had used more than one million pounds of TEL in 1950 to a base allotment of one million pounds plus 80 percent of their 1950 consumption in excess of the base. Those that used less than the base amount in 1950 were allowed their full 1950 consumption.

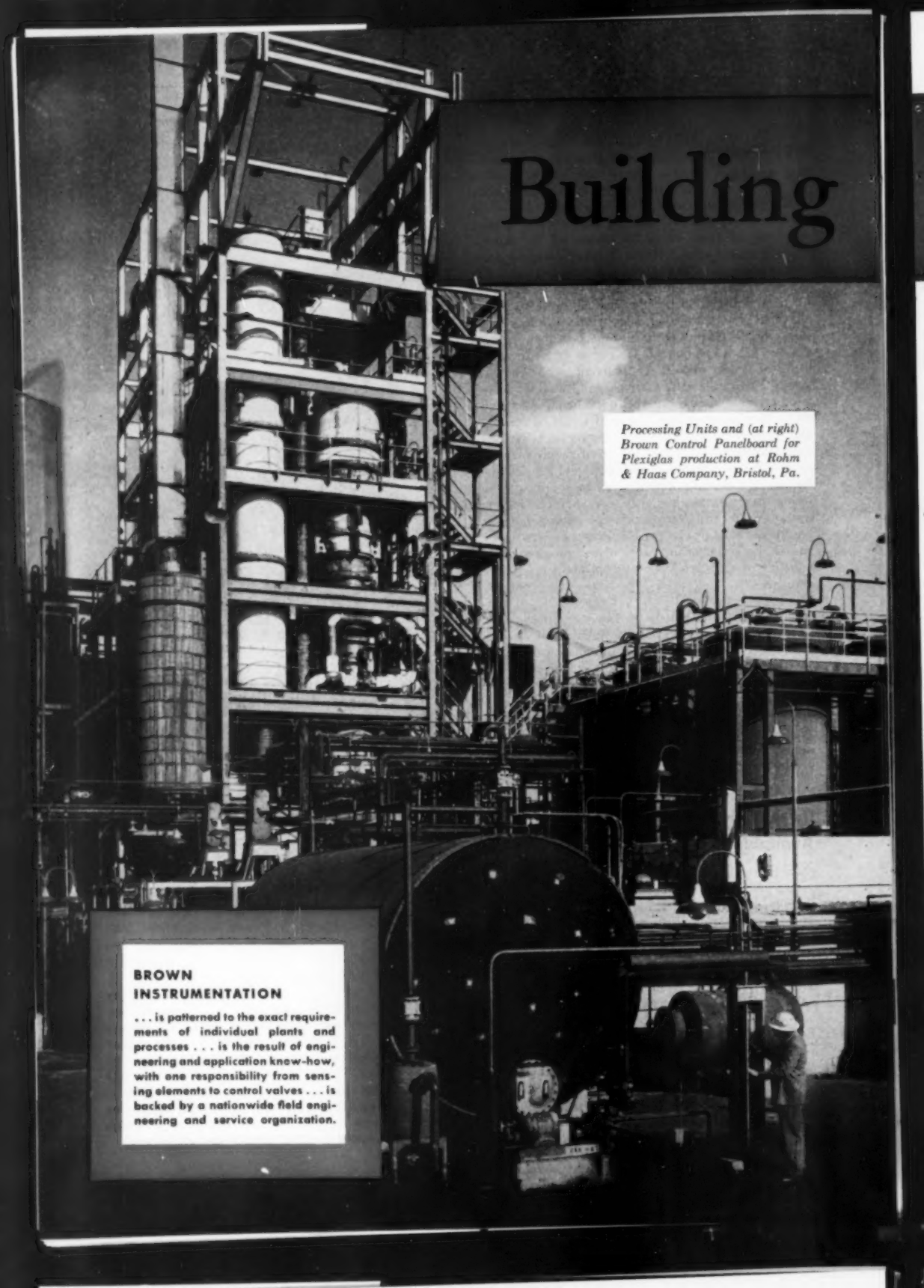
Looking To Future For Management

AN ESTIMATED 60 percent of the potential managerial talent of engineers is being lost to industry today, due to poor communications between engineers and the top management of industry. This was disclosed in a nationwide survey of 350 industrial companies employing some 50,000 engineers. Conducted by the National Society of Professional Engineers, the survey showed that 99 percent of the firms have engineers in top executive positions and 92 percent look to their engineers for future leaders.

Only 34 percent of the companies have any planned program of information and indoctrination to prepare engineers for future management leadership. This lack of adequate communications between company managements and their engineers is depriving industry of at least 60 percent of the potential managerial talent possessed by their engineers.

Following up the survey with an improvement formula, the society suggests the preparation of an "engineering audit" which individual companies can apply to determine how effective are particular communications with their engineers. The audit is recommended as a first step so management will have a guide on what engineers want to know about their company and how management can tell its story most effectively. The audit will find the basis for a communications policy which can use a variety of communications techniques.

The next step of the formula is a plan for the review and test for effectiveness of communications methods and media, using the audit findings as a guide. The third step suggested by the report is the designation of a single top management man to be responsible for effective engineering-management communications. It is suggested that the top engineering executive should have this responsibility because he has the greatest stake in the improved productivity of his engineers.



Processing Units and (at right) Brown Control Panelboard for Plexiglas production at Rohm & Haas Company, Bristol, Pa.

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Control of every significant step in this polymerization process is synchronized by efficient, coordinated Brown Instrumentation. From a centrally located panelboard, these instruments insure precise regulation of even the most complex exothermic reactions, where process variables must stay within stringent limits.

When choosing recording and controlling instruments for your vinyl polymerization process, or *any* polymerization process, consider first:

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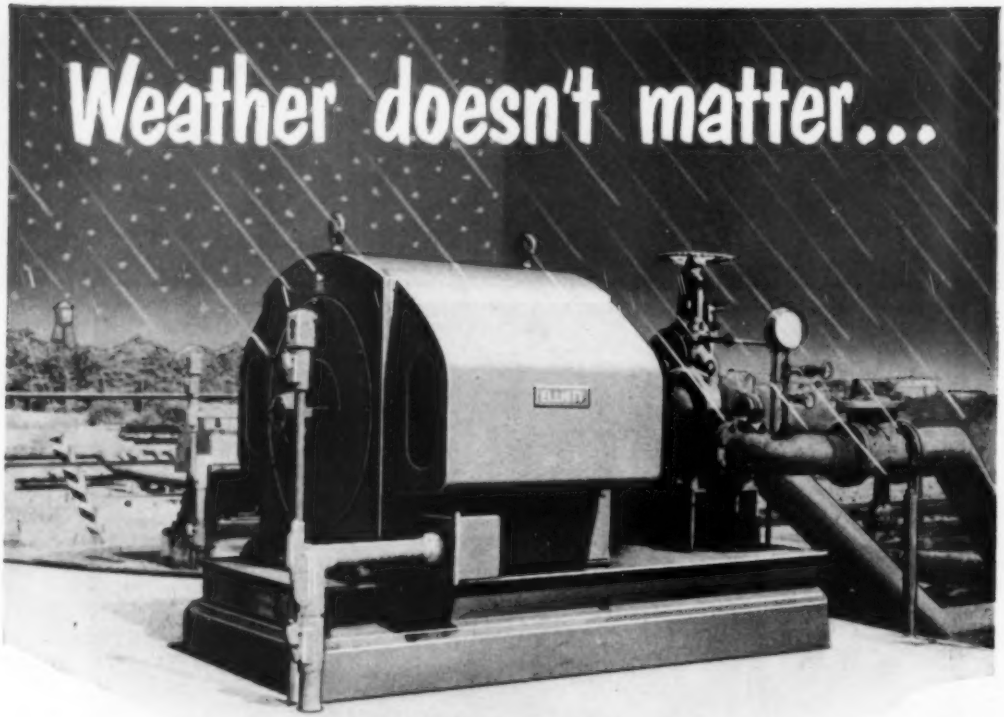
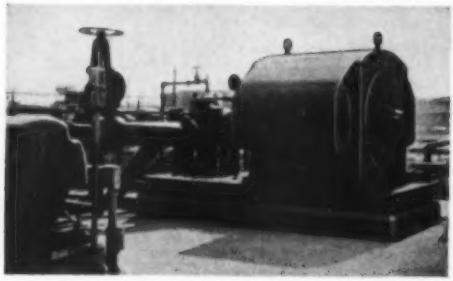


...to the ELLIOTT OUTDOOR SPLASHPROOF MOTOR!



Top picture: Elliott 250 hp. outdoor motor driving pump in a refinery, exposed to the battering winter storms sweeping across three thousand miles of the North Atlantic.
Just above: Another view of the installation, showing also, at left, a smaller Elliott Crocker-Wheeler motor.

• Howling blizzard, sleet, tropical deluge, fog, salt spray, dust-storm—none of them have anything to say to this tailored-to-the-job Elliott "Fabri-Steel" squirrel-cage induction motor, shown in the photo above driving a pump for an important northeastern oil refinery. This motor saves three ways—(1) makes housing unnecessary—(2) makes special vented foundation unnecessary, needing only a simple slab—(3) makes awkward piping layout unnecessary, since you can put it just where you want it, regardless of cover.

Built in third frame above NEMA and larger. The Outdoor Motor Bulletin, PB-7000-3, gives full data. On request.

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Postwar Refinery Construction In Foreign Lands Hits Fast Pace

Yankee Dollars have helped in work particularly in Europe, but modernization and expansion program generally has been worldwide

SINCE 1945 refining capacity in countries outside the United States has gained 150 percent, jumping from 2,016,113 barrels daily to 5,040,000 barrels. The increase will be 4,155,487 barrels daily or more than 200 percent as soon as construction for an additional 1,131,600 barrels daily, now under way, has been completed.

These figures, from a survey made by PETROLEUM REFINER, indicate the tremendous impact of foreign refinery construction upon the oil industry, but, at that, the world has taken it in stride, accustomed as it seems to be to superlatives from petroleum.

United States, of course, has been even busier along this line. Postwar demand for refined products has continued to ascend almost in an unbroken curve. To meet this cry for more and more products, oil companies have set forth on a refinery building program that spurted for four years, appeared to quiet down for a spell, but since the Korean action started, has again burst forth in gigantic proportions.

FOREIGN REFINING PICTURE

COUNTRY	CRUDE CAPACITY 1945	1951-52	Increase	Building
Canada	218,615	427,800	209,185	28,000
Mexico	149,700	228,000	78,300	40,000
Puerto Rico	.....	25,000	25,000	.....
Aruba-Curacao	453,000	677,000	224,000	.....
Trinidad	75,000	100,000	25,000	.....
Argentina	96,400	124,150	27,500	.....
Bolivia	.....	6,000	6,000	.....
Brazil	.....	56,000	56,000	110,000
Chile	.....	.....	.....	14,000
Colombia	14,000	25,840	11,840	10,000
Peru	29,000	37,900	8,900	.....
Uruguay	8,000	25,000	17,000	.....
Venezuela	137,078	387,370	250,292	90,000
United Kingdom	91,100	500,400	409,300	106,200
France	36,900	367,300	330,400	11,500
Germany	22,670	162,240	139,570	90,300
Italy	6,000	302,800	296,800	33,500
Belgium	.....	37,300	37,300	25,000
Canary Islands	10,000	16,000	6,000	.....
Morocco	.....	2,200	2,200	.....
Netherlands	.....	93,500	93,500	8,000
Portugal	4,600	4,600	.....	8,000
Scandinavia	9,000	27,000	18,000	21,000
Spain	.....	25,000	25,000	3,000
South Africa	.....	.....	.....	19,100
Switzerland	1,500	1,500	.....	.....
Turkey	1,400	1,400	.....	3,000
Saudi Arabia	53,000	180,000	127,000	103,000
Bahrein	60,000	190,000	130,000	.....
Egypt	36,650	47,000	10,350	.....
Iran	380,000	540,000	180,000	.....
Iraq	11,000	18,500	7,500	26,000
Israel	40,000	80,000	40,000	.....
Kuwait	.....	25,000	25,000	.....
Lebanon	3,000	11,000	8,000	.....
Syria	.....	5,000	5,000	15,000
Australia	2,500	21,100	18,600	222,000
Borneo	.....	65,500	65,500	18,000
Burma	.....	2,000	2,000	3,000
India	4,000	4,000	.....	70,000
Japan	62,000	50,000	12,000*	11,000
Java	20,000	139,600	119,600	30,000
Philippines	.....	.....	.....	13,000
Total	2,016,113	5,040,000	3,023,837	1,131,600

* Decrease.

TYPICAL OF POSTWAR European refinery construction is this Shell Stanlow refinery near Ellesmere Port, Cheshire, England. Shown in this night view is a fluid catalytic cracker under construction. In the right foreground are water cooling towers and on the left storage for liquefied petroleum gas. In the distance is the chemical plant.

Active Foreign Front

During these same postwar years, there has been anything but quiet on the foreign front. The peoples of virtually every country in the world, it might be said, have awakened to the advantages that come with the use of petroleum products and this growing demand has been met by a refinery building program that surpasses any wild guess that might have been made in 1945.

The survey figures:

3,023,887 barrels daily capacity (150 percent) already added, and

1,131,600 barrels daily capacity now under construction, for a 4,155,487-barrel total gain in daily capacity (206.1 percent).

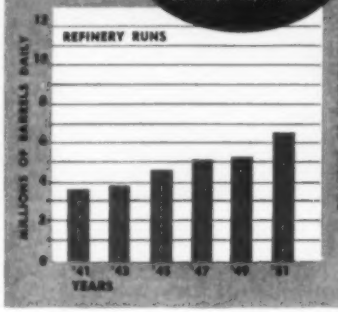
These figures, as pointed out, do not include U. S. domestic expansion nor do they include refinery construction, if any, that has gone on in Iron Curtain countries.

Uncle Sam dollars have had a big part in many of the projects that are listed on the tables that accompany this survey report. This help has been extensive and widespread, with the major portion going to European coun-

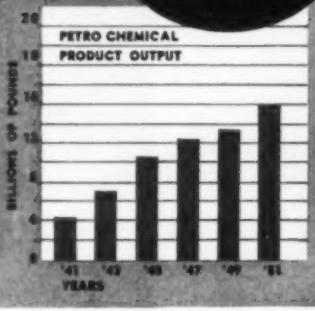
CONFIDENCE spells growth

There's many a reason for the parallel growth of the Petro Chemical Industry and the increasing use of Petro-Chem Iso-Flow Furnaces by leading Petro Chemical Companies.

Runs to stills in U. S. oil refineries increased from 3 million 500 thousand barrels per day in 1940 to more than 6 million 500 thousand barrels per day in 1951



Petro Chemical production has increased from 4 billion pounds in 1940 to more than 16 billion pounds in 1951.



In 1940 there was 1 In 1946 there were 400 and as of Feb 1952 there are more than 1000 Petro-Chem Iso-Flow Furnaces performing in the petroleum, chemical and allied industries.

ISO-FLOW FURNACE USERS KNOW . . . that the Petro-Chem Development Company has but one basic product; processing furnaces for petroleum, chemical and allied industries. As a result of experience, they know that it does not pay to build their own furnaces; that Petro-Chem Iso-Flow Furnaces cost less, operate efficiently and usually beyond their rated capacity . . . they know that all process data made available for the design and engineering of Petro-Chem Iso-Flow Furnaces is kept strictly confidential . . . never released by Petro-Chem Development Company engineers.

The Petro Chemical, Petroleum, Chemical and allied industries can be confident that as they grow in size and advance in technology, so Petro-Chem Iso-Flow Furnaces will keep pace.

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for any **DUTY TEMPERATURE PRESSURE EFFICIENCY**

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CANADA

LOCATION	Company	CRUDE CAPACITY 1945	1951-1952	Increase	Building
Nova Scotia					
Imperoyal (Dartmouth)	Imperial Oil Limited	34,000	32,000	12,000*	.....
New Brunswick					
Weldon	New Brunswick Oilfields, Ltd.	250	300	50	.....
Quebec					
Montreal—East	Imperial Oil Limited	25,000	46,000	21,000	.....
Montreal—East	The British American Oil Co., Ltd.	12,000	40,000	28,000	.....
Montreal—East	McColl-Frontenac Oil Co., Ltd.	16,000	43,000	27,000	.....
Montreal—East	Shell Oil Company, Ltd.	10,000	28,000	18,000	.....
	Total	63,000	157,000	94,000	.....
Ontario					
Clarkson	The British American Oil Co., Ltd.	8,250	12,500	4,250	5,000
Petrolia	Canadian Oil Cos.	3,000	4,000	1,000	.....
Froomfield	Canadian Oil Cos.		20,000	20,000	.....
Toronto	McColl-Frontenac Oil Company	13,000	Shutdown 1949	13,000*	.....
Sarnia	Imperial Oil Ltd.	41,500	57,000	15,500	14,000
Port Credit	Trinidad Leaseholds (Canada Ltd.)	4,000	7,000	3,000	.....
	Total	69,750	100,500	30,750	19,000
Manitoba					
Brandon	Anglo-Canadian Oils Ltd.	2,000	3,000	1,000	.....
East St. Paul	Imperial Oil Ltd.		12,000	12,000	.....
Morris	Trump Oil Co., Ltd.	Idle	300	300	.....
St. Boniface	North Star Oil Ltd.	1,500	3,000	1,500	.....
East Kildonan	Radio Oil Refineries Ltd.	1,000	1,250	250	.....
	Total	4,500	19,550	15,050	.....
Saskatchewan					
Moose Jaw	The British American Oil Co., Ltd.	4,000	6,000	2,000	9,000
Vermilion	France Oils Ltd.		3,000	3,000	.....
Sakatoon	Hi-way Refineries Ltd.	300	3,650	3,350	.....
Rosetown	Hi-way Refineries Ltd.	275	350	75	.....
Moose Jaw	Hi-way Refineries Ltd.	300	Idle	300*	.....
Regina	Imperial Oil Ltd.	10,500	20,000	9,500	.....
Moose Jaw	Moose Jaw Refineries, Ltd.	300	1,000	700	.....
Prince Albert	Prince Albert Refineries, Ltd.	500	1,000	500	.....
Regina	Saskatchewan Federated Corporatives, Ltd.		5,900	5,900	.....
Kamsack	Northern Petroleum Corporation	400	800	400	.....
	Total	16,575	41,700	25,125	9,000
Alberta					
Edmonton	The British American Oil Co., Ltd.		5,750	5,750	.....
Calgary	The British American Oil Co., Ltd.	4,500	7,200	2,700	.....
Lloydminster	Excelsior Refineries		3,000	3,000	.....
Hartell	Gas & Oil Refineries, Ltd.	3,000	2,500	500*	.....
Lloydminster	Husky Oil Refining Ltd.		10,000	10,000	.....
Edmonton, Alta.	Imperial Oil Ltd.		22,600	22,600	.....
Ogden	Supreme Refineries Ltd.		500	500	.....
Wainwright	Wainwright Refineries, Ltd.	300	300		.....
Calgary	Imperial Oil Ltd.	10,300	9,200	1,100*	.....
Edmonton	McColl-Frontenac Oil Co.		5,500	5,500	.....
	Total	18,100	66,550	48,450	.....
Northwest Territories					
Norman Wells	Imperial Oil Ltd.	840	1,250	410	.....
British Columbia					
Ioco	Imperial Oil Ltd.	2,600	7,600	5,000	.....
Shellburn	Shell Oil Co. of Canada Ltd.	4,000	3,000	1,000*	.....
Burnaby	Standard Oil Co. of British Columbia	5,000	8,350	3,350	.....
	Total	11,600	18,950	7,350	.....
	Grand Total	218,615	427,800	209,185	28,000

* Decrease.

SOUTH AMERICA

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Argentina					
Avellaneda	Cia. Condor	1,300	1,300	.....	.....
Avellaneda (Dock Sud)	Ultramar, S.A.	6,000	Closed	6,000*	.....
Avellaneda	Lottero y Papinia, Cia	600	950	350	.....
Bahia Blanca	Cia. la Isaura, S.A.	3,000	5,000	2,000	.....
Bahia Blanca	Esso Refinadora de Petroleo, S.A.	3,000	3,800	800	.....
Buenos Aires	Diadema Argentina, S.A., de Petroleo	8,000	13,500	5,500	.....
Buenos Aires, (Wilde)	Cia. General Asfaltos (B.A.)	500	800	300	.....
Campana	Esso Refinadora de Petroleo, S.A.	16,000	Closed	16,000*	.....
Comodoro Rivadavia	Yacimientos Petroliferos Fiscales	8,000	8,000	.....	.....
Dadin	Esso Petroleum de Petroleo, S.A	400	400	.....	.....
Lujan de Cuyo	Y.P.F.	6,000	6,000	.....	.....
Manuel Elordi	Esso Petroleum de Petroleo, S.A.	1,000	1,000	.....	.....
Plaza Huincul	Y.P.F.	1,200	1,500	300	.....
Puerto la Plata	Y.P.F.	30,000	55,000	25,000	.....
Salta	Y.P.F.	1,900	1,900	.....	.....
San Lorenzo	Y.P.F.	9,500	25,000	15,500	.....
	Total	96,400	124,150	27,750	.....
Bolivia					
Sucre	Government	New	1,000	1,000	.....
Cochabamba	Government	New	5,000	5,000	.....
Brasil					
Capuava	Refinaria e Exploracao do Petroleo	New	.....	.....	25,000
Cubatao	Conselho Nacional do Petroleo	New	.....	.....	45,000
Manguinhos	Refinaria do Petroleo do Distrito Federal	New	.....	.....	10,000
Mataripe	Conselho Nacional do Petroleo		5,000	5,000	.....
Niteroy	Brazilian Investments: Max Leitao	New	.....	.....	20,000
Pindamonhangaba		Shale Oil	.....	.....	10,000
Rio Grande du Sul	Ipiranga S.A., Cia. Brasileira de Pet.	Unknown	2,500	2,500	.....
Salvador	Conselho Nacional de Pet.	New	2,500	2,500	.....
Santos	Conselho Nacional do Pet.	New	45,000	45,000	.....
Sao Paulo	Industrias Matarazzo do Energia	New	1,000	1,000	.....
	Total	.....	56,000	56,000	110,000
Chile					
Concon	Corp. de Fomento de la Production	New	.....	.....	14,000
Colombia					
Barranca-Bermeja	Empresa Colombiana de Petroleos	14,000	25,000	11,000	10,000
Petrolea Camp	Colombian Petroleum Company	.....	840	840	.....
Peru					
Agua Caliente	Cia. Ganso Azul	1,000	1,000	.....	.....
Talara	International Petroleum Company	27,000	35,600	8,600	.....
Zorritos	Empresa Petrolera Fiscal	1,000	1,300	300	.....
Uruguay					
Montevideo	ANCAP	8,000	25,000	17,000	.....
Venezuela					
Amuay Bay	Creole Petroleum Corporation	New	60,000	60,000	.....
Cabimas	Mene Grande Oil Co.		1,800	1,800	.....
Cardon	Shell	New	83,000	83,000	80,000
Caripito	Creole Pet. Corp.	38,000	65,000	27,000	.....
El Menede Mauros	British Controlled Oilfields, Ltd.	250	250	.....	.....
Guario	Socony-Vacuum Oil Company		120	120	.....
Jusepin	Creole Petroleum Co.	40,000	40,000	.....	.....
La Salina	Creole Pet. Corp.	10,828	Closed	10,828*	.....
Mulata	Mene Grande Oil	New	20,000	20,000	.....
Oficina	Mene Grande Oil Co.		2,200	2,200	.....
Puerto La Cruz	Sinclair	New	35,000	35,000	.....
Puerto La Cruz	Venezuelan Gulf Refining Co.	New	30,000	30,000	.....
San Lorenzo	Shell Caribbean Petroleum Co.	38,000	40,000	2,000	.....
San Roque	Phillips Petroleum Company	New	.....	.....	10,000
Tucupita	Texas Petroleum Co.	10,000	10,000	.....	.....
	Total	137,078	387,370	250,292	90,000
	GRAND TOTAL	284,478	662,250	377,782	224,000

Note: Only Argentina, Brazil and Venezuela carry individual totals.

* Decrease.

tries such as United Kingdom, France, Germany and Italy. An announcement by ECA about a year ago (PETROLEUM REFINER, June, 1951), for instance, told of 14 refineries that were being modernized, expanded or constructed in Western Europe with the aid of Marshall-Plan financing in projects approved "in the last three years." Estimated cost of these projects were shown as the equivalent of $234 million of which $35 million was ECA dollar financing.

The current survey did not embrace costs but was limited

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Boston	Detroit	Minneapolis	Providence	
Chicago	Houston†	Newark	Rochester†	(†sales office only)
Cincinnati	Indianapolis	New Orleans	St. Louis	

MEXICO and PUERTO RICO

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Mexico					
Atsacapotsalco	Petroleos Mexicanos	50,000	50,000	.....	.....
Ciudad Madero	PEMEX	43,000	75,000	32,000	.....
Guaymas	PEMEX	Plan	.....	.....	.....
Manatlan	PEMEX	Plan	.....	.....	30,000
Minatitlan	PEMEX	27,000	28,000	1,000	.....
Reynosa	PEMEX	.....	4,000	4,000	.....
Salamanca	PEMEX	New	30,000	30,000	.....
Salina Cruz	PEMEX	Plan	.....	.....	10,000
Arbol Grande	PEMEX	11,500	22,000	10,500	.....
Mata Redonda	PEMEX	15,000	15,000	.....	.....
Poza Rica	PEMEX	3,200	4,000	800	.....
	Total	149,700	228,000	78,300	40,000
Puerto Rico					
Ponce	Puerto Rican Oil Ref.	.....	25,000	25,000	.....
	Grand Total	149,700	253,000	103,300	40,000

LESSER ANTILLES

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Aruba	ArendPetroleum Mij.	35,000	42,000	7,000	.....
Aruba	Lago Oil & Transport Co.	300,000	360,000	60,000	.....
Curacao	N.V. Curacaosche Petroleum	118,000	275,000	157,000	.....
	Total	453,000	677,000	224,000	.....
Trinidad					
Point Fortin	United British Oilfields	25,000	30,000	5,000	.....
Point-a-Pierre	Trinidad Leaseholds	50,000	70,000	20,000	.....
	Total	75,000	100,000	25,000	.....
	Grand Total Lesser Antilles	528,000	777,000	249,000	.....

FRANCE

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
D'Ambes	GIRONDE	Inoperable	15,000	15,000	1,500
Berre-Etang	Shell-Berre	Closed	63,000	63,000	.....
Courcheletes	SGHP	Inoperative	750	750	.....
Donges (St. Nazaire)	Francaises de Petrole de l'Atlantique	Inoperative	15,000	15,000	.....
Dunkirk	SGHP	Inoperative	36,000	36,000	.....
Frontignan	Socony-Vacuum Francaise	4,700	15,000	10,300	.....
Gonfreville ("Normandie")	Compagnie Francaise de Raffinage	Inoperative	57,000	57,000	.....
Gravenchon (Notre Dame)	Socony-Vacuum Francaise	Inoperative	17,000	17,000	.....
L'Avera	SGHP	12,200	36,000	23,800	.....
Merkwiller, Alsace	Pechelbronn S.A.E.M.	Inoperable	1,250	1,250	.....
Pauillac	Shell-Berre	Inoperable	6,300	6,300	4,500
Port Jerome	Standard Francaise des Petroles	Inoperable	40,000	Rebuilt 40,000	3,500
Provence (La Mede)	Shell-Berre	20,000	20,000	.....	.....
Petit-Couronne	Shell-Berre	Nil	45,000	45,000	.....
	Total	38,900	367,300	330,400	11,500

to daily capacity of crude thruput. Forty-odd countries are shown in the tabulation.

Greatest increases in daily capacity since 1945 are these: United Kingdom gained 409,000 barrels daily capacity; France gained 330,000 barrels; Italy, 296,000 barrels, and Germany, 139,000 barrels. These four countries have under construction at this time a further capacity totaling some 250,000 barrels daily.

Much of the crude required for these plants—and this is true for many other refineries—will come from the heavy producing fields of the Near East.

The Near East countries themselves, as might be expected, have also participated in this world-wide refinery

GERMANY

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Bremen-Oslebshausen	Deutsche Vacuum Oel AG	1,900	12,700	10,800	.....
Cologne	Coelner Benzin-Raffinerie GmbH	*	330	330	.....
Dedenhausen (Hanover)	Mineraloelwerke Albert Sengewald	*	900	900	.....
Dollbergen-Wietze	Deutsche Gasolin	1,000	2,500	1,500	.....
Dollbergen (Hanover)	Georg Greiner/ Pfeifer	*	800	800	.....
Duesseldorf-Reisholz on Rhine	Deutsche Shell A.G.	Inoperative	900	900	.....
Eislingen	Zeller & Gmelin	170	170	.....	.....
Essen	Kraftstoff-Handelsgesellschaft mbH	*	750	750	.....
Gelsenberg	Standard Vacuum	*	Closed	.....	.....
Gelsenkirchen, Scholven		*	Closed	.....	.....
Gelsenkirchen	Gelsenberg Benzin AG	*	17,000	17,000	.....
Grasbrook, Hamburg	Mineraloelwerke Abrect Co.	Inoperative	250	250	.....
Hamburg (Eurotank)	AIOC	Inoperative	1,500	1,500	.....
Hamburg-Finkenwerder	B P Deutsche Benzin and Petroleum Gmb. H.	3,400	14,000	10,400	30,000
Hamburg-Grasbrook	Deutsche Shell AG.	*	1,700	1,700	.....
Hamburg-Harburg (Ebano)	Ebano Asphalt-Werke A.G.	9,000	11,000	2,000	25,000
Hamburg-Harburg	Esso AG.(Standard of New Jersey)	*	15,000	15,000	.....
Hamburg-Harburg	Shell	inoperable	10,400	10,400	.....
Hamburg-Neuhof	Oelwerke Julius Schindler GmbH.	*	4,200	4,200	.....
Hamburg, Wilhelmsburg	Deutsche Erdoel	Nil	850	850	.....
Hamburg, Wilhelmsburg	Johann Halterman	Nil	2,100	2,100	.....
Hamburg, Wilhelmsburg	Ernst Jung	Nil	120	120	.....
Heide, Schleswig-Holstein	Deutsche Erdoel	Inoperative	3,000	3,000	.....
Lingen, Holtshausen	Gewerkschaft Erdoel Raff. Emsland	New	.....	.....	12,000
Ludwigshafen-Oppau	Badische Anilin and Soda Fabrick	Inoperative	1,000	1,000	.....
Muelheim-Ruhrbau		Inoperative	.....	.....	.....
Manheim on Rhine	Deutsche Shell Akt. Gesellschaft Shell Haus	Inoperative	4,200	4,200	.....
Misburg, Hanover	GewerkschaftDeurag-Nerag (Esso)	5,000	11,200	6,200	.....
Neuhof, Hamburg	AIOC	2,000	2,000	.....	.....
Ostermoor-Kiel Canal	Mawag	Inoperative	1,300	1,300	.....
Oberhausen-Holten	Ruhrchemie A.G.	Inoperative	5,300	5,300	.....
Peine, Hanover	Oelw Julius Schindler	Nil	380	380	2,300
Ruhrol		*	Closed	.....	.....
Salzbergen	Wintershall	Inoperative	2,000	2,000	.....
Wedel on Elbe	Deutsche Vacuum Oil	.....	750	750	.....
Wietze-Krein, Hanover	Deutsche Erdoel	*Converted	1,400	1,400	.....
Wesseling	Deutsche Shell A.G.	*Converted	15,000	15,000	.....
Wesseling	Union Rheinische Braunkohlen-Kraftstoff AG.	*	17,000	17,000	.....
Wilhelmsburg	Deutsche Shell A.G.	Inoperative	850	850	.....
	Total	22,670	162,240	139,570	90,300

* Coal hydrogenation plants during Nazi regime.

UNITED KINGDOM

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Ardrossan	Shell Refg. & Mrtg.	4,300	4,300	.....	.....
Camperdown	Wm. Briggs	.....	1,000	1,000	.....
Coryton	Vacuum Oil Co.	New	.....	.....	18,000
Dundee	Wm. Briggs & Sons	700	700	.....	.....
Ellesmere Port	Lobitas Oil Field	1,800	2,500	700	.....
Ellesmere Port	Anglo-American Oil Co., Ltd.	New	500	500	.....
Fawley	Anglo-American Oil Co., Ltd.	21,000	134,000	113,000	.....
Grangemouth	Scottish Oil Co., Ltd.	7,500	45,000	37,500	17,500
Heysham	Shell Refg. & Mktg.	12,500	37,500	25,000	.....
Isle of Grain, Kent	AIOC	New	40,000	40,000	40,000
Kingsnorth	Berry Wiggins	800	2,600	1,800	.....
Llandarcy	National Oil Refineries	7,500	84,000	76,500	.....
Partington	Petro-Chemicals, Ltd.	.....	.....	.....	.....
Pumpherston	Scottish Oil Co., Ltd.	3,700	3,700	.....	.....
Shell Haven	Shell Refg. & Mktg.	13,000	57,000	44,000	.....
Southampton	Caltex & Trinidad Leasehold	New	45,000	45,000	.....
Stanlow	Shell Refg. & Mktg.	15,500	37,700	22,200	30,000
Trafford Park	Manchester Oil Refg.	2,800	2,800	.....	700
Wenste	Berry Wiggins	New	1,500	1,500	.....
	Total	91,100	500,400	409,300	106,200

OTHER EUROPE AND AFRICA

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Belgium					
Antwerp	S.I.B.P. Petrofina (AIOC)	New	27,000	27,000	.....
Antwerp	Raff. Belge de Petroles	Nil	8,000	8,000	.....
Antwerp	Esso Standard	New	.....	.....	25,000
Ghent	Belgian Shell	Nil	2,300	2,300	.....
Canary Islands					
Teuerife	CEPSA	10,000	16 000	6,000	.....
Morocco					
Petitjean	Societie Cherifienne des Petroles	Unknown	2,200	2,200	.....
Netherlands					
Pernis	Shell	Nil	73,500	73,500	.....
Pernis	Caltex	New	20,000	20,000	8,000
Portugal					
Cabo Ruivo	SACOR	4,600	4,600	.....	8,000
Scandinavia					
Copenhagen		Plan	.....	.....	21 000
Gotenburg	Koppartans	New	12,500	12,500	.....
Malmo	Johnson	1,000	1,000	.....	.....
Nynashamo	A. Johnson & Co.	8,000	12,000	4,000	.....
Vallo	A/s Norsk Amerikanask Mineraloljekomagni	None	1,500	1,500	.....
Spain					
Escombreras (Cartegena)	Caltex	None	25,000	25,000	.....
Puertollano	Empresa Nacional Calvo Sotelo	Shale Oil	.....	.....	3,000
South Africa					
Coalbrook	SASOL	Syntheris	.....	.....	3,500
Durban	Vacuum Oil	New	.....	.....	15,000
Vall River	Consol. Investment	Synthesis	.....	.....	.....
Switzerland					
Rotkreuz		1,500	1,500	.....	.....
Turkey					
Ramandaz	MTA	New	.....	.....	3,000
Batman (Ankara)	MTA	1,400	1,400	.....	.....
	Grand Total, Europe and Africa	26,500	208,500	182,000	87,100

NEAR EAST

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Saudi-Arabia					
Aden	AIOC	Plan	.....	.....	103,000
Ras Tanura	ARAMCO	53,000	180,000	127,000	.....
Bahrein	BAPCO	60,000	190,000	130,000	.....
Egypt					
Suez	Raff. de Petrole da Govt.	3,650	9,000	5,350	.....
Suez	Anglo-Egyptian Oil Fields, Ltd.	33,000	38,000	5,000	.....
Iran					
Abadan	Government	360,000	540,000*	180,000	.....
Iraq					
Alwand	Government	.....	7,500	7,500	.....
Baghdad	Government	Plan	.....	.....	24,000
Kirkuk	Iraq Petroleum Co.	11,000	11,000	.....	.....
Basra	Government	Plan	.....	.....	12,000
Israel					
Haifa	Government	40,000	80,000†	40,000	.....
Kuwait	Kuwait Oil Co.	New	25,000	25,000	.....
Lebanon					
Tripoli	Iraq. Petroleum Co.	3,000	11,000	8,000	.....
Sidon	Caltex	Plan	.....	.....	.....
Syria	French Government	New	5,000	5,000	15,000
	Grand Total, Near East	563,650	1,096,500	532,850	154,000

* Closed down. Nationalized 1951.

† In partial operation since 1946.

building program, as, for that matter, have the countries of the Far East. Iran (180,000 barrels daily increase), Bahrein (130,000 barrels) and Saudia Arabia (127,000

• CONTINUED ON PAGE 96

ITALY

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Apuania	Shell	New	.....	.....	.....
Ancona	AIP	New	10,000	10,000	.....
Augusta, Sicily		New	10,000	10,000	.....
Bari	STANIC	6,000	35,000	29,000	.....
Massa Carrara	INPET	New	40,000	40,000	.....
Cortemaggiore	Raffinerie di Petrolio "Italia"	New	.....	.....	4,000
Fornova Taro	Societa Petrolifera Italiana	Inoperative	4,500	4,500	.....
Genoa (Naples)	Vacuum Italiana Sp. A.	Inoperative	35,000	35,000	.....
Leghorn	STANIC	Inoperative	15,500	15,500	14,500
La Spezia	PETROLIO	Inoperative	17,000	17,000	13,000
Rho	CONDOR	New	30,000	30,000	.....
Milan (Genoa)	PERMOLIO	Inoperative	10,000	10,000	.....
Mantuva	ICIP	New	4,500	4,500	.....
Palermo	AGIP	New	7,500	7,500	.....
Rome	PERMOLIO	Inoperative	24,000	24,000	.....
San Martino	SARPOM	New	13,300	13,300	.....
Trieste	AQUILA	Inoperative	18,000	18,000	.....
Ste-Sabba, Trieste	SIAP	.....	2,500	2,500	.....
Porto Marghera (Venice)	IROM	Inoperative	26,000	26,000	2,000
	Total	6,000	302,800	296,800	33,500

FAR EAST AND OCEANIA

Location	Company	CRUDE CAPACITY 1945	1951-2	Increase	Building
Australia					
Aden	AIOC	New	.....	.....	100,000
Altona	Vacuum Oil Co.	New	1,800	1,800	14,000
Clyde NSW	Australian Shell	New	8,800	8,800	.....
Fremantle	AIOC	New	.....	.....	60,000
Geelong	Australian Shell	New	.....	.....	26,000
Laverton	COR	2,500	2,500	.....	.....
Sydney, Matraville	Bitumen Oil & Refs.	New	8,000	8,000	.....
Sydney (Kurnell)	Being Formed	.....	.....	.....	22,000
	Total	2,500	21,100	18,600	122,000
Borneo					
Balik Papan	N.V. de Bataafsche Maatschappij	Inoperable	27,000	27,000	18,000
Lutong	Sarawak Oil Fields, Ltd.	Inoperable	38,500	38,500	.....
Burma					
Syriam	Burmah Oil Co.	Nil	2,000	2,000	3,000
India					
Bombay	Burmah Shell	Plan	.....	.....	30,000
Bombay	Standard-Vacuum	Plan	.....	.....	20,000
N.E. Calcutta	Assam Oil Co.	4,000	4,000	.....	.....
Vizagapatam	Caltex	Plan	.....	.....	20,000
Vizagapatam	Koppers	Plan*	.....	.....	.....
	Total	4,000	4,000	.....	70,000
Japan					
Kawasuki	Mitsubishi	4,000†	3,000	.....	.....
Kawasuki	Showa	6,000	4,000	.....	.....
Kudamatsu	Nippon	6,000	7,000	1,000	.....
Marifu	Koa Oil	5,000	10,000	.....	5,000
Mutsuyama	Maruzen	11,800	Shut-Down	.....	.....
Shikoku Island	Taiyo Oil	.....	.....	.....	.....
Shimizu	Toa Neuryo	5,000	4,000	.....	.....
Shimotsu	Maruzen	7,000	3,000	.....	.....
Wakagama	Toa Neuryo	10,000	6,000	.....	.....
Yokahama	Nippon	6,000	12,000	.....	6,000
Yokkaichi	Daikyo Oil	1,200	1,000	.....	.....
	Total	62,000	50,000	1,000	11,000
Java					
Tjepoe	N.V. de Bataafsche Pet. Mij.	Inoperable	27,000	27,000	.....
Wonokromo	N.V. de Bataafsche Pet., Mij.	Inoperable	3,600	3,600	.....
Pangkalan Brandan	N.V. de Bataafsche Pet., Mij.	Inaccessible	.....	.....	.....
Pladjoe	N.V. de Bataafsche Pet., Mij.	20,000	75,000	55,000	.....
Soengei Gerong	N.V. Standard Vacuum Pet., Mij.	Inoperable	34,000	34,000	30,000
	Total	20,000	139,600	119,600	30,000
Philippine Islands					
Batangas	Caltex (P.I.) Inc.	.....	.....	.....	13,000
	Grand Total, Far East and Oceania	88,500	282,200	206,700	367,000

Note: Borneo, Burma and Philippine Islands no not carry individual totals.

* Plan 2 coal synthesis plants.

† Pacific Coast refineries shut down 1944 for lack of crude. Current Japanese figures represent operating capacity under allocation regulations.

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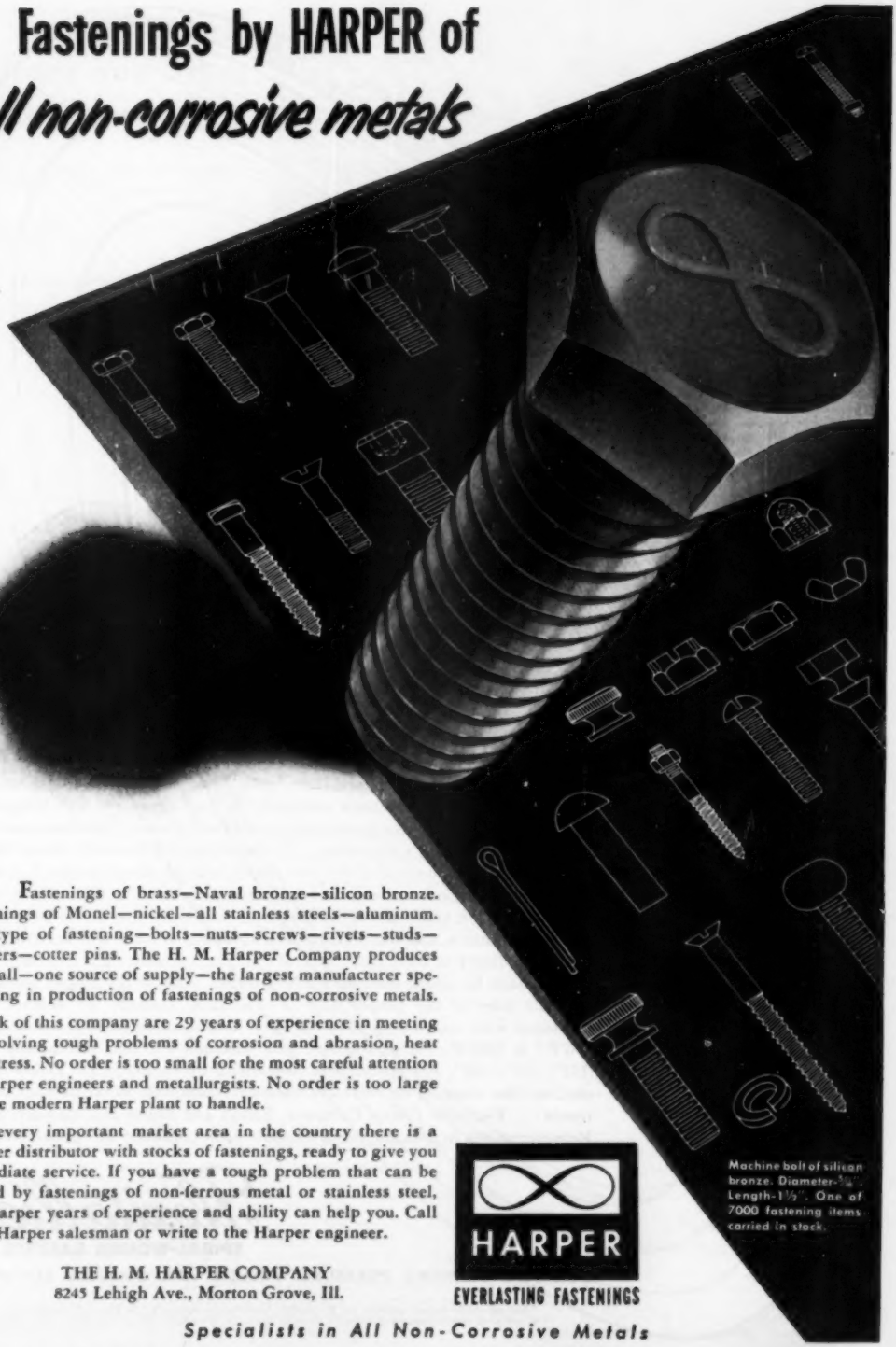

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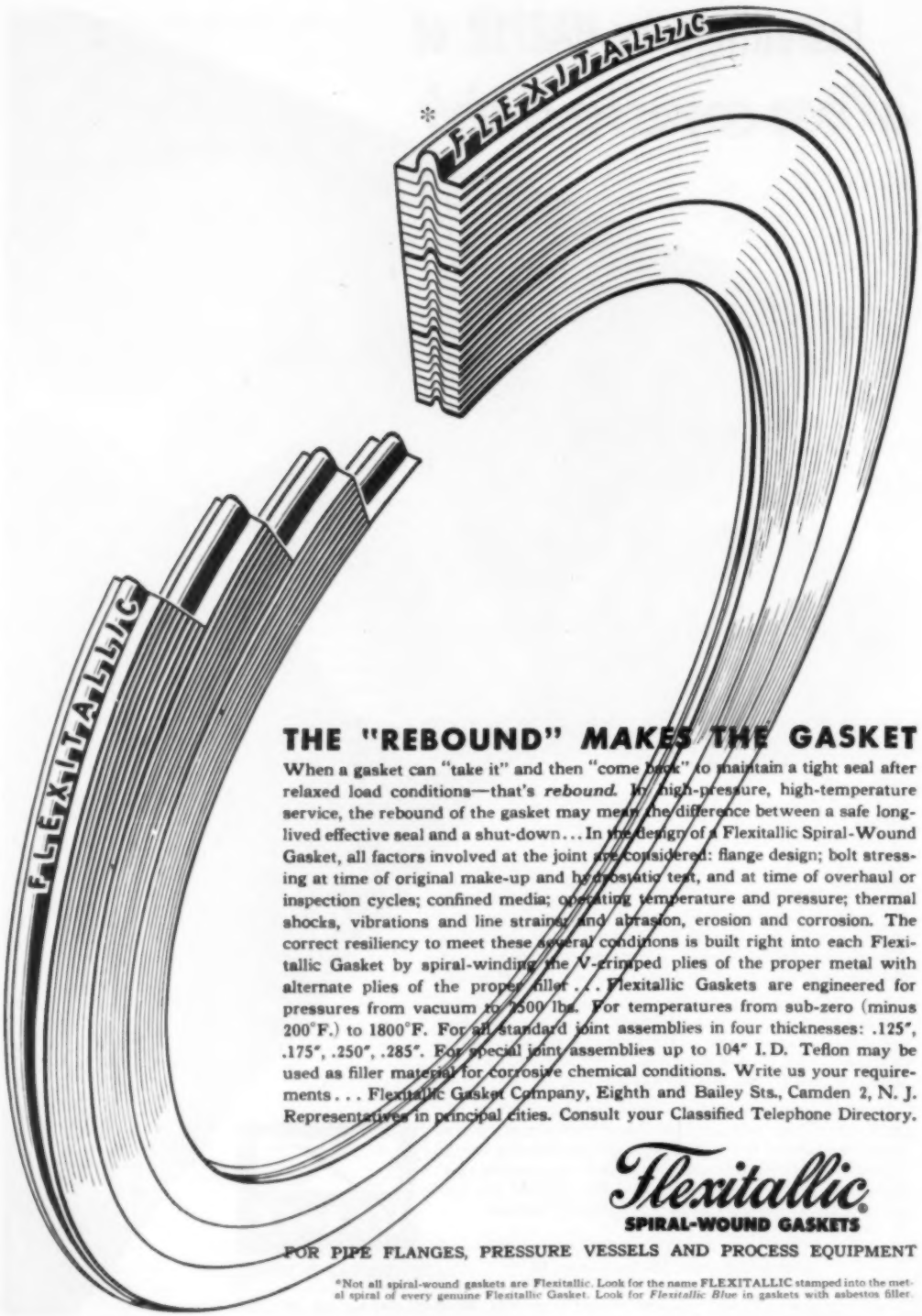

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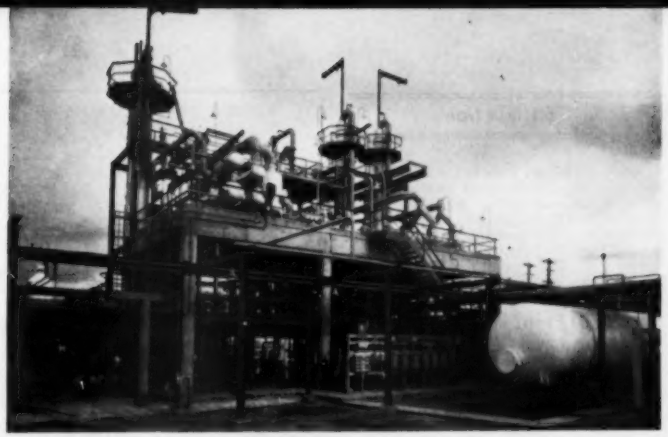
Refinery and Other Plant Construction

Petroleum Refiner's next "boxscore" tabulation will appear in the July issue.



NEW UNIT IN OPERATION—A new unit for the production of monoethanolamine, diethanolamine and triethanolamine at Jefferson Chemical Company, Inc's., Port Neches, Texas, plant was placed in operation recently. Jefferson thus becomes the third United States producer of these chemical intermediates. One principal use of the ethanolamines is as a gas scrubbing agent for the removal of hydrogen sulfide and carbon dioxide. The hydrogen sulfide may be processed and recovered as elemental sulfur, and the carbon dioxide converted to dry ice. Other uses are as intermediates in the preparation of surface active agents which are used in synthetic detergents, textile specialties, waxes and polishes, herbicides, cosmetics, cutting oils and cement additives, and as agents in the manufacture of antibiotics.

Brazilian Refinery Being Enlarged, Capacity Doubled

Expansion to twice its present 2500 barrels per day capacity is underway at Conselho Nacional do Petroleo's combination thermal refinery at Mataripe, State of Bahia, Brazil. Also, catalytic polymerization is being added, and modifications made to the original plant, completed in 1950, to process any of the lighter crudes now available from local fields. The completed plant will include topping, vis-breaking, therma reforming and cracking, stabilization and light ends recovery, in addition to catalytic polymerization and liquefied petroleum gas facilities. The M. W. Kellogg Company is engineer-contractor, with Kellogg Pan American Corporation supervising construction.

Canadian Bechtel Awarded Imperial Refinery Contract

Canadian Bechtel Ltd. of Vancouver has been awarded the contract for the major part of a $13,500,000 construction program at Imperial Oil Company's Ioco refinery near Vancouver, B. C. Ground preparation is scheduled to start immediately with erection of new equipment to begin in early fall, and completion is expected by the fall of 1953. The expansion program will raise the refinery capacity from 12,000 to 22,500 barrels per day. A fluid catalytic cracking unit with a capacity of 7600 barrels a day is part of the program. Other equipment to be erected includes atmospheric and vacuum distillation units, a gas recovery unit and a treating plant.

Continental To Construct $1,750,000 Gasoline Plant

Continental Oil Company has announced plans for construction of a $1,750,000 gasoline recovery and gas repressuring plant in the Sussex oil field in Johnson county, Wyo. The Continental installation will be the first of its type in the immediate area. The company operates a similar plant at Lance Creek and is part owner of a natural gasoline plant at Elk Basin in Wyoming. Company spokesmen have announced that the new plant will enable Continental to recover more than a million barrels additional oil during a 20-year period through the repressuring method of injecting gas back into the producing reservoirs in the area. It will also make available for sale about 13 million cubic feet of natural gas and will recover approximately 300,000 barrels of natural gasoline from the compression of natural gas.

AIOC's $90 Million Plant To Be Australia's Largest

Anglo-Iranian Oil Company's Australian expansion plans call for the erection of a $90 million refinery with a daily capacity of 60,000 barrels. The refinery will be the largest in the commonwealth. Located at Kwinana, on Cockburn Sound near Freemantle, the plant will be able to meet the requirements of Anglo-Iranian's Australian associates, company officials have estimated. Being located near Freemantle, the refinery is near one of the country's main bunkering ports and is said to be favorably placed for tankers coming from the Middle East, which will be the source of crude oil supply.

Frontier to Boost Refining Capacity at Tonawanda Plant

Frontier Oil Refining Corporation has started a $6-million expansion and modernization program at its 17,000-barrel-per-day plant at Tonawanda, N. Y. The company, a subsidiary of Ashland Oil and Refining Company, will increase the capacity to 25,000 barrels per day and install a new 13,000 barrel-per-day Fluid catalytic cracking unit. Construction of the Fluid unit is being handled by Arthur G. McKee & Company, while Catalytic Construction Company has the contract for auxiliary and off-site facilities, including revamping of the poly plant, new kerosine treating unit, new boiler house and new loading facilities.

Three Italian Refineries To Have Increased Capacities

The Italian Ministry of Industry has confirmed reports that, though having stopped the issuance of further concessions to build new refineries in Italy, it has authorized the enlargement of the yearly crude oil processing capacity of the Garrone, Permolio and Esso Standard Italiana refineries in Genoa of about 2,326,200 barrels per year over the present figure.

Field Work Underway on Two Ashland Refining Plants

The Catalytic Construction Company has announced that it has begun field work in Catlettsburg, Ky., and Tonawanda, N. Y., on extensive new facilities for Ashland Oil and Refining Company. In Catlettsburg, the principal work involves a 11,000 barrel-per-day vacuum unit to produce gas oil for catalytic cracking feed from reduced crude. A synthetic crude tower will permit an increase in catalytic cracking capacity from 22,000 to 27,000 barrels per day. At Tonawanda, Catalytic's contract covers all off-site facilities including steam, power, water and fuel, river water pumping facilities, tankage, tank car and tank truck loading facilities and separator, shops and warehouses. In addition there is extensive revamp of existing equipment to meet new process requirements, including a cat poly unit and kerosine treating. Completion of field work at Tonawanda is expected around the end of 1952, and at Catlettsburg during the second quarter of this year.

New Italian Refinery to Be Put On Stream by Next Fall

A new 13,300-barrel-per-day refinery being built at San Martino di Trecate in northern Italy by Societa per Azioni Raffineria Padana Olii Minerali (Sarpom) is expected to be put on stream before next fall. Progress is being paralleled in modernization of a marine terminal at Savona from which the refinery will be supplied with Middle East crude by a 97-mile pipe line. Sarpom is jointly owned by Caltex and Fiat interests.

Sun Oil To Build Aromatics Plant At Marcus Hook Refinery

Sun Oil Company has engaged The Kuljian Corporation of Philadelphia to prepare process design drawings for a portion of a new aromatics plant to be located at their Marcus Hook refinery.

In addition to aromatics, the new facilities will produce aviation gasoline, propane, butane and other light fractions. Design work is already started and construction is scheduled to begin in the near future on $12-million plant.

Lion To Build $31 Million Chemical Plant At Luling

Lion Oil Company has announced it has filed a registration statement with the Securities and Exchange Commission providing for the offering of stock which will provide funds for the construction of a new chemical plant estimated to cost $31 million. The plant will be designated as the Barton Plant and will be located at Luling, La., north of New Orleans on the Mississippi river. The plant will have a capacity for the daily production of 300 tons of anhydrous ammonia, the greater part of which will be converted into prilled ammonium nitrate. Natural gas for raw material and fuel will be supplied by The Texas Company.

Gulf Builds New Blending Plant In South Carolina

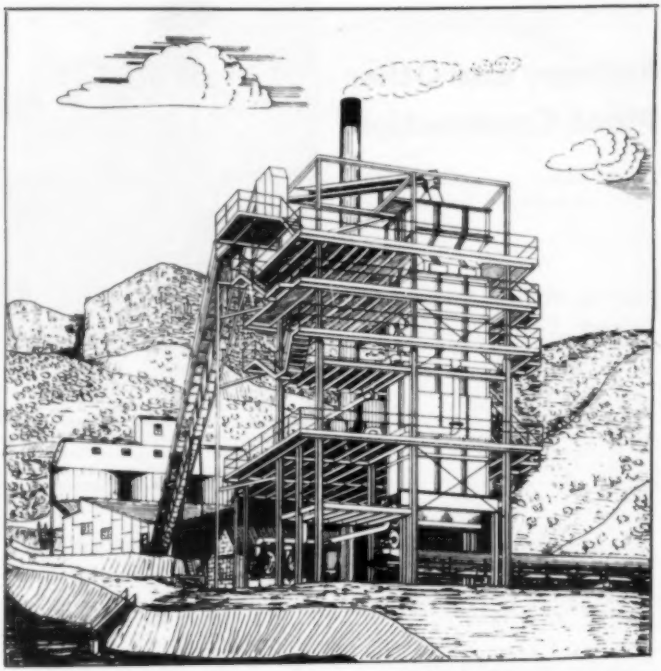
The Gulf Oil Corporation has announced completion of its new canning, drumming and blending plant at its present terminal on Ship Yark Creek, Charleston, South Carolina. The new plant will blend and package one- and five-quart cans as well as five-gallon cans, five-gallon pails, 55-gallon drums, 14-gallon drums, and possibly other sizes of branded motor oils and a large line of industrial oils for immediate distribution in North and South Carolina and Georgia. The new canning plant will supply approximately 90 percent of finished packaged goods for distribution to Gulf outlets in the area.

DPA OK's 18-Month Foreign Petroleum Expansion Program

The Defense Production Authority has approved a foreign oil expansion program which calls for the expansion of refining capacity by 576,000 barrels per day in addition to the drilling of 10,000 additional wells, adding 3800 miles of pipe lines, plus installing 35,360,000 barrels of storage capacity. Approval of both the foreign program and a previously announced domestic program calls for a total expenditure of $10 billion.

$2.6-Million Dow Chemical Research Center Being Built

Construction of an eight-building laboratory and research center for the Dow Chemical Company's Texas division is underway at Freeport, Texas, and completion is expected within 15 months. The contract for the estimated $2.6-million project has been awarded to the Southwestern Construction Company of Houston. In the 69,000 square feet of this new construction will be centered the organic research, chemical engineering research, electro-chemical research, and analytical laboratory, in addition to administrative offices, a patent office and a library.



RIFLE PLANT READY SOON—This sketch shows the general appearance of the Bureau of Mines 300-ton-per-day demonstration retort being constructed at Rifle, Colo., at a cost of $333,870. The new retort and accompanying equipment will take the place of two batch-type retorts that had been used earlier to provide oil for refining studies and engineering information useful in designing the continuous process. Experimental operation of the demonstration plant is expected to provide the engineering information required for projecting the design to industry-scale plants. The commercial gas-combustion retort would have a capacity of several thousand tons daily. The refractory for lining the retort has not yet been received and instrumentation and sampling equipment is yet to be installed, as well as the remainder of the piping and some of the feeding, discharging and conveying equipment. Expected completion date is July 1, 1952.

Certificate of Necessity Granted on Phenol Plant

Jefferson Chemical Company, Inc., has announced that it has been granted a certificate of necessity for the construction of nonyl phenol and dinonyl phenol manufacturing facilities at its Port Neches, Texas, plant. Construction of the new unit was begun in September, 1951, and is scheduled for completion within the next two or three months. Nonyl phenol and dinonyl phenol are used as intermediates in the manufacture of anionic and nonionic surface active agents and as starting materials for lube oil additives, stabilizers, petroleum demulsifiers, oil-soluble phenolic resins and plasticizers.

Kellogg Company to Build Indiana Standard Plant

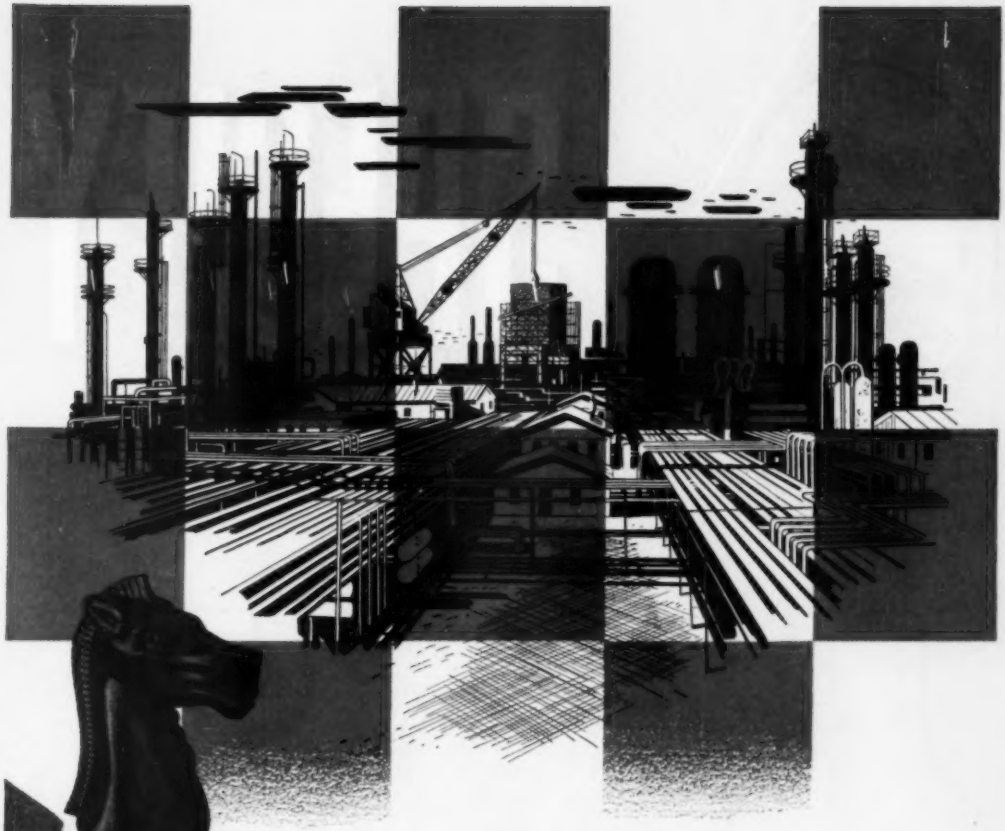
The M. W. Kellogg Company has been awarded the contract to construct a large iso-octyl alcohol plant at its Wood River, Ill., plant by Standard Oil Company (Indiana). The plant will have three basic parts: fractionation system and refinery gas reformer to be designed by Kellogg, and an actual iso-octyl alcohol section designed by Indiana Standard.

Humble Plans New Paraxylene Plant at Baytown Refinery

Humble Oil & Refining Company's projected new paraxylene plant at its Baytown, Texas, refinery is the latest addition to the Gulf Coast area's expanding petrochemical industry. The plant, scheduled for completion in May, 1953, will produce more than two million pounds of paraxylene a month. Construction gets underway in September, and materials are being purchased by C. F. Braun Construction Company, the builder. The object of the Baytown plant will be to obtain substantialy pure paraxylene from a crude mixture of hydrocarbons containing ortho, meta, and paraxylenes, ethyl benzene and about one percent non-aromatics. The process developed by Humble research engineers is one of separation and purification.

UOP Platforming Unit to Be Installed in Canary Islands

Work will begin shortly on the installation of a 5000-barrel-per-day UOP Platforming unit for Compania Espanola de Petroleos, S.A. The unit will be constructed at the company's refinery located at Santa Cruz, Tenerife in the Canary Islands. This is the 30th Plat-



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forming unit to go into design and brings the total design capacity of the units in operation or under construction to approximately 115,000 barrels daily. The CEPSA unit, which is scheduled for completion in late 1953 or early 1954, is being built primarily for motor fuel production, which will be marketed in the CEPSA's typical markets. The unit will operate for seven days per stream month for the production of aromatics, charging a Venezuelan crude stock. During the other 23 days, it will produce motor fuel, charging primarily a Kuwait stock, plus Venezuelan naphthas left from the aromatic operation. Construction will be by Procon, Inc.

Ceremonies Mark Start of South African Construction

Ceremonies marking the start of construction on Standard-Vacuum Oil Company's $17-million fuel products refinery near Durban, South Africa, were held recently. The 15,600-barrel-per-day refinery is being built by Stanvac's new manufacturing subsidiary, Standard-vacuum Refining Company of South Africa, (Pty.), Ltd., on a 285-acre site in Wentworth, a Durban suburb. Foster-Wheeler Corporation is the general contractor. The new plant will process crude oil from Middle East sources.

Detergent Additive Output Hiked by Indiana Standard

A new plant will be built by Standard Oil Company (Indiana) at its Wood River, Ill., refinery to expand production of an improved detergent additive used in compounding heavy duty motor oils. The new plant is being designed by Indiana Standard. Construction, to begin shortly, will be completed in '53.

DPA Approves Projects for Rapid Tax Amortization

Projects which have received the Defense Production Administration's approval for rapid tax write-offs, in addition to those earlier ones shown in the accompanying table, are as follows:

Reef Fields Gasoline Corporation, Borden and Howard counties, Texas, natural gasoline plant, $4,900,485, 65 percent, $1,246,960, 40 percent; Sun Oil Company, Marcus Hook, Pa., acid oils, $3,257,925 at 65 percent, $661,500 at 40 percent; Southeastern Michigan Gas Company, Port Huron, Mich., natural gas, $4,298,650, 25 percent; Ben Franklin Refining Company, Ardmore, Okla., petroleum products, $2,750,000 at 40 percent.

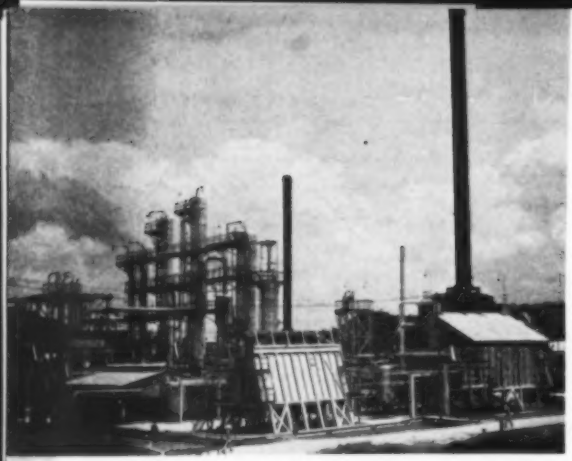
Shell Oil Company, Beckham, Okla., natural gasoline, $1,495,861 at 65 percent, $440,000 at 40 percent; William O. Morse, Clay County, Texas, natural gasoline, $94,000 at 65 percent; $31,000 at 40 percent; Phillips Oil Company, Phillips, Texas, propylene polymer of alkylation feed, $294,000 at 65 percent. 40 percent; Warren Petroleum, Monument, N. M., natural gasoline, $80,462, 65 percent.

Phillips Oil, Kansas City, Kan., propane, $269,000 65 percent; Phillips Petroleum Company, Gray county, Texas, natural gasoline residue gas, $92,000, 40 percent.

Fast Tax Write-Offs

Granted by DPA February 16 to March 17.

COMPANY and LOCATION	Type of Facility	Amount Amort. Applied For	Amount Certified	Percent Allowed
Esso Standard Oil Company, Linden, N.J.	Isobutylene, polybutene, and additives for lube oils	8,529,900	6,480,9 1,148,180	65 45
The Atlantic Refining Company, Philadelphia, Pa.	Aviation Alkylate	29,500,000	450,000 9,661,500 16,460,500 2,928,000	15 45 65 90
L. Sonneborn Sons, Petrolia, Pa.	Petroleum Sulfonates	750,000	349,000 273,000 128,000	65 50 15
Morton-Withers Chemical Company, Greensboro, N.C.	Petroleum Sulfonates	1,780,742	1,236,438 353,314 186,000	65 45 15
Ashland Oil & Refining Company, Louisville, Ky.	Gasoline Refining	1,190,000	585,000 605,000	65 45
Standard Oil Company (Ohio), Lima, O.	Alkylation Feedstock	12,375,000	7,987,000 4,388,000	65 40
Standard Oil Company (Ohio), Cleveland, O.	Gasoline and Alkylation Feedstock	6,710,000	1,787,600 1,744,400 3,187,000	65 45 25
Sun Oil Company, Marcus Hook, Pa.	Acid Oils	4,868,200	3,257,925 661,500	65 40
Monsanto Chemical Company, Monsanto, Ill.	Additives for Oils	1,646,000	87,900 798,050 760,050	15 40 65
Oronite Chemical Company, Oak Point, La.	Lube Oil Additives	581,200	316,630 153,770 83,800	50 30 10
Ethyl Corporation, Baton Rouge, La.	Antiknock Compounds	4,155,300	1,563,700 2,591,600	65 80
Reef Fields Gasoline Corporation, Borden and Howard Cos., Tex.	Natural Gasoline	6,202,445	4,900,485 1,246,960	65 40
Old Dutch Refining Company, Muskegon, Mich.	Benzene Toluene	326,100	326,100	40
Standard Oil Company (Indiana), Wood River, Ill.	Motor Oil Additives	1,300,000	130,000 130,000 930,000	15 40 65
Phillips Petroleum Company, Great Falls, Mont.	Refining	1,500,000	1,135,000 365,000	65 45
Stanolind Oil & Gas Company, Grant Co., Kan.	Natural Gasoline	3,381,000	3,327,000 54,000	65 40
Hugoton Production Company, Ulysses, Kan.	Butane and Propane	300,000	280,603	65
Panhandle Eastern Pipe Line Company, Kansas City, Mo.	Isobutane and Propane	510,000	510,000	55
Stanolind Oil & Gas Company, Grant County, Kan.	Isobutane for Avgas Production	286,000	286,000	90
Pan-Am. Southern Corporation, El Dorado, Ark.	Polybutylene	250,000	215,000	65
Texas City Refining Company, Texas City, Tex.	Aviation Alkylate	2,500,000	2,480,000	50
Cities Service Oil Company, Pampa, Tex.	Gasoline	231,267	222,139	70
Esso Standard Oil Company, Baton Rouge, La.	Cetyl Alcohol	477,000	326,000	70
Sinclair Refining Company, Houston, Tex.	Barium Sulphonate	175,000	98,650 23,700 23,480	65 50 15
Warren Petroleum Corporation, Tulsa, Okla.	Propane and Butane	844,340	566,320	65
Phillips Petroleum Company, Ector Co., Tex.	Propane and Butane	5,466,400	3,765,800 1,680,600	65 40
Phillips Petroleum Company, Borger, Tex.	Propane and Isobutane	2,165,055	111,418 1,852,050	40 65
Del Ray Petroleum Company, Eagle Lake, Tex.	Natural Gasoline, Butane and Propane	371,422	364,009 7,413	65 15
Deep Rock Oil Corporation, Cushing, Okla.	High V.I. Lubes	1,850,000	1,625,000 225,000	65 45
Shell Oil Company, Deer Park, Tex.	Hydrogen Sulfide	86,500	86,500	70
Shell Oil Company, Deer Park, Tex.	Avgas Components	1,000,000	1,000,000	90
Magnolia Petroleum Company, Midland & Upton Co., Tex.	Natural Gas & Butane	8,385,406	7,086,210 1,237,239 26,955	65 40 25
Barnhart Hydrocarbon Corporation, Big Lake, Tex.	Propane	38,098	38,098	65
Warrent Petroleum Corporation (Operator), Maysville, Okla.	Propane and Butane	1,451,472	1,451,472	55
Shell Chemical Corporation, Houston, Tex.	Ethyl Chloride	9,500,000	6,232,000 412,000 410,000	65 45 15
Phillips Petroleum Company, Gray/Co., Tex.	Natural Gasoline	92,000	92,000	40
Standard Oil Company of Texas, Snyder, Tex.	Isobutane and Natural Gasoline	941,000	393,400 677,600	90 65
Warren Petroleum Corporation, McLean, Tex.	Natural Gasoline	91,933	87,242	40
Stanolind Oil & Gas Company, Hockley Co., Tex.	Gasoline Production	1,076,000	1,076,000	65
The Texas Company, Scurry Co., Tex.	Propane, Butane and Natural Gasoline	3,760,000	608,699 3,128,479	40 65
Sid Richardson Gasoline Company, Winkler Co., Tex.	Propane and Butane	600,000	600,000	65
Phillips Petroleum Company, Hutchinson Co., Tex.	Natural Gasoline	98,228	94,873	40
Magnolia Petroleum Company, Longville, La.	Natural Gasoline	705,900	557,102 142,000	65 40
Shell Oil Company, Notrees, Tex.	Natural Gas Process	1,140,000	1,139,000	65
Phillips Petroleum Company, Brazoria Co., Tex.	Natural Gasoline	240,000	237,745	65
H. W. Bass & Sons, Inc., Live Oak Co., Tex.	Propane and Butane	1,925,530	976,295	65
Taylor Refining Company, Port Isabel, Tex.	Refined Petroleum Products	1,302,375	1,033,015 269,360	65 40
Mayfair Minerals, Inc., Port Isabel, Tex.	Petroleum Products	1,831,963	1,184,014 630,449 1,500	65 40 15
Skelly Oil Company, Stephens & Carter Co., Okla.	Natural Gasoline	1,100,000	965,500 130,000	65 40
Bel Oil Corporation, Elton, La.	Natural Gasoline	145,000	145,000	65
Phillips Petroleum Company, Borger, Tex.	Natural Gasoline	732,000	393,720 272,905	40 65
Skelly Oil Company, Lea Co., N. M.	Natural Gasoline	2,500,000	2,500,000	65
Union Oil Company of California, Wilmington, Calif.	Elemental Sulfur	450,000	416,000 34,000	70 45
Standard Oil Company of California, Richmond, Calif.	Lubricating Oils	1,050,000	980,700 50,500 40,000	65 40 15
Shell Oil Company, Martinez, Calif.	Sulphonates	476,000	414,000 62,000	65 40
Union Oil Company of California, Oleum, Calif.	Petroleum Products	84,780	84,780	65
Quimico, Contra Costa Co., Calif.	Tetraethyl Lead	1,367,000	1,022,000 115,500	75 45
Shell Chemical Corporation, Martinez, Calif.	Lube Oil Detergents	790,000	78,600 787,050 21,350 11,600	15 65 45 15
Wilmington Gasoline Company, Los Angeles, Calif.	Natural Gasoline	292,000	292,000	65
Standard Oil Company of California, Richmond, Calif.	Lube Oils	470,000	35,000 435,000	15 65



THE FIRST BRAZILIAN *refinery to produce cracked gasoline, put on stream early in 1951, at Bahia by Refinaria Nacional de Petroleo, S. A., contains a complete combination crude distillation and thermal cracking plant and is capable of processing 2500 barrels of crude daily. All currently operating or projected Brazilian processing plants have been developed since the end of World War II.*

Postwar Construction

• CONTINUED FROM PAGE 88

barrels) are the top three there and Saudia Arabia is continuing its program with 103,000 barrels additional daily capacity under construction.

The Far East, after suffering the ravishes of a thoroughgoing war, is beating back in admirable fashion. Its gain since 1945 has been a respectable 205,000 barrels daily and at this time units with a daily capacity of 367,000 barrels are under construction.

Australia's activity, for convenience, is included in this total. It alone accounts for a 222,000-barrel-capacity figure that is now under construction. India has 70,000 barrels of capacity being built and Java, already a heavy gainer over its 1945 figures, is adding 30,000 barrels daily.

Japan's situation is that its current capacity is some 12,000 barrels less than the indicated 1945 figure although there is under construction units of 11,000 barrels daily.

It should be explained that Japanese refineries now operate at 85 percent of stream time due to crude allocation. Most of these plants were not operating in 1945 so the "1945 Crude Capacity" figures shown actually represent the capacity in 1944 when lack of crude forced them to shut down. Small inland refineries that existed on native crude were in operation continuously 1940-52. Pacific Coast refineries were allowed to resume limited operations in 1950.

Generally, it should be pointed out here that while war area plants were badly damaged and not put officially on stream, they were for the most part being used, with limited operations, of course—in 1945. The majority of European plants were on stream in 1946, many of them with 1940 capacities already reached. This thought is offered so as to clarify company reports of "inoperable" that show in some of the accompanying tables.

Actually the only refineries not urgently in need of modernization in 1945 were the plants on the islands off the coast of Venezuela, those of the Near East and, of course, those in the United States.

South American countries, as may be noted, have been most active. Brazil, for instance, has a 56,000-barrel-daily capacity now whereas in 1945 there were no native plants turning out petroleum products. A figure twice this amount, 110,000 barrels is listed as the daily capacity of units presently being built.

Aruba and Curacao during the postwar period posted a daily gain of 224,000 barrels and Venezuela increased its daily capacity by 250,000 barrels with another 90,000 barrels being built at this time. Some of the factors that brought about this gain are listed below.

Chile has yet to enter the refining product column but has under way a plant that will turn out 14,000 barrels daily.

Mexico, proud of its record, has 228,000 barrels daily capacity now which represents a gain of 78,000 barrels over 1945. An additional 40,000 barrels daily is being constructed, the government has announced.

Canada, which struggled along for the first few years after the war, is now a hot spot and during the next few years likely will hang up an enviable record for processing its ever increasing flow of crude oil. Its gain since 1945 is shown as 209,185 barrels daily with another 28,000 barrels that will be coming shortly from plants now under construction.

Foreign Investment Figures

Of interest in connection with this foreign postwar construction survey are figures offered by the U. S. Department of Commerce (Survey of Current Business, January, 1951) which show that American private direct investments abroad were valued at $12.5 billion on December, 31, 1949 compared with $8.4 at the end of 1945. The figures for petroleum investments is shown as gaining $2.1 billion during that period or nearly half the gain for all industries (manufacturing, public utilities, mining and smelting, distribution and agriculture) combined. The 1945 total was given at $1.5 billion and the 1949 total at $3.6 billion. Oil represented 18.4 percent of the total in 1945 and 29.5 of the 1949 total. Only manufacturing, at 31.2 percent, a slight drop from its 1945 figure, exceeded the petroleum investment in 1949.

F. G. Coqueron, The Chase National Bank, New York, in commenting on these Department of Commerce figures pointed out that "at the close of World War II, the petroleum industry engaged in a long-range program to meet potential war demand, which materially exceeded prewar consumption. Large prewar reserves of low-cost crude oil were also available for development outside the U. S., particularly in the Middle East. Among the factors inducing additional investments was a modification of the Venezuelan petroleum law which requires that 10 percent of its crude oil output be refined in that country. This development necessitated allocation of substantial funds by American and other companies for the construction of refineries.

"The net increase of approximately $2.1 billion in the value of petroleum investments abroad during the postwar period represents the development of crude oil producing properties in Canada, the Middle East and Venezuela; the construction of pipe lines in the Middle East and Venezuela; the acquisition of tankers; and the installation of refining facilities in the Middle East, Venezuela and Western Europe."

The Commerce Department's figures show that Latin America drew down 46.4 percent of American private investments made abroad in petroleum, Europe 23.9 percent, Canada 9.7 percent and all other countries 20 percent.

In connection with the postwar foreign construction program presented herewith, the reader is reminded that PETROLEUM REFINER presents each quarter (January, April, July and October issues) a complete "boxscore" of refinery and other plant construction which presents in detail the current construction picture, both foreign and domestic.

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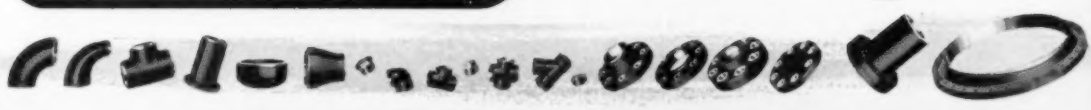


TWO TERRY TURBINES IN RECORD NON-STOP RUN AT CITIES SERVICE

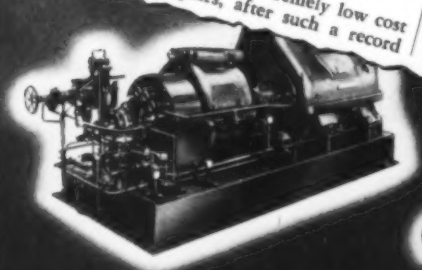
After 26 Months of Continuous Operation, Cost of Replacement Parts Only $78.00 for Each Turbine

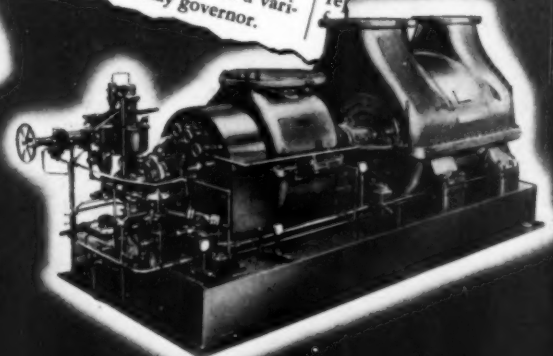
Two Terry turbines recently completed a record non-stop run at the East Chicago refinery of Cities Service Oil Company. Specially designed for driving air blowers on fluid catalytic cracking, they ran continuously *from initial start up*, day and night, for two years and two months. Throughout the entire run neither turbine suffered any noticeable reduction in efficiency.

On inspection, after shutdown, it was found that the only parts showing signs of wear were the shaft packing rings. These were replaced at a total cost of $78.00 for each turbine.

While this extremely low cost for repairs, after such a record run, could not have been anticipated, Cities Service had good reason to expect outstanding performance from Terry turbines. A four-year record of 216 Terry turbines at the Lake Charles refinery of this same company showed amazingly low maintenance costs. During this period, the yearly cost of replacement parts averaged only 1.4% of the initial investment.

The two turbines at East Chicago are rated 2450 horsepower at 5030 rpm. Each is equipped with a trip throttle valve, forced feed lubrication, and regulator for process control applied to a variable speed oil relay governor.





For more information about Terry multistage turbines, send for a copy of Bulletin S-146. No cost or obligation.

TERRY

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

TT-1193

Production of High-Purity Aromatics for Chemicals

DAVIS READ
Universal Oil Products Company
Chicago

PRESENTED HERE are pilot plant Platforming and Udex extraction data obtained to illustrate the application of these two processes for the production of high purity low-boiling aromatics. Platforming data were obtained on two cuts from Gulf Coast straight-run gasoline to show the over-all results obtainable in both a blocked-out aromatics-motor fuel operation and a combined aromatics-motor fuel operation. The economics of these two operations were worked out by projecting the pilot plant data to an operation in which 10,000 barrels per stream day of gasoline are processed. On this basis, the over-all economic studies show that nitration grade benzene, toluene and xylenes can be produced together with high octane premium motor gasoline with a pay-out time of two years before taxes.

DURING the past few years, the predicted increase in demand for low-boiling aromatics for chemicals has provided the primary incentive for the tremendous expenditures by the petroleum industry to improve processing methods.

Also refiners are becoming more aware of the possibilities of applying conventional oil refinery processing methods and efficiency to the production of the so-called petrochemicals. Considerable experience has been gained in the operation of certain types of process units which are normally utilized to produce gasoline but which can be modified to produce these chemical intermediates. An example is the polymerization process which was installed originally for gasoline manufacture but is now being utilized for production of propylene tetramer, a chemical intermediate for detergent manufacture, or for the alternate production of isopropylbenzene which is oxidized in a separate step to produce phenol and acetone. Another example is the use of the alkylation process to alkylate benzene with propylene tetramer to produce detergent alkylate. Many of these units are operated by the refinery personnel. In other cases, subsidiary companies have been organized to operate the units in a location adjacent to the refinery. Similar methods are now being followed by the petroleum industry in installing process units for manufacturing aromatics and it appears that this trend will continue.

Although the problem of supplying large quantities of low-boiling aromatics was given to the oil industry only a relatively short time ago, there is no question that the industry can pro-

Original presentation was before the 17th mid-year meeting of the American Petroleum Institute's Division of Refining, San Francisco, May 14, 1952.

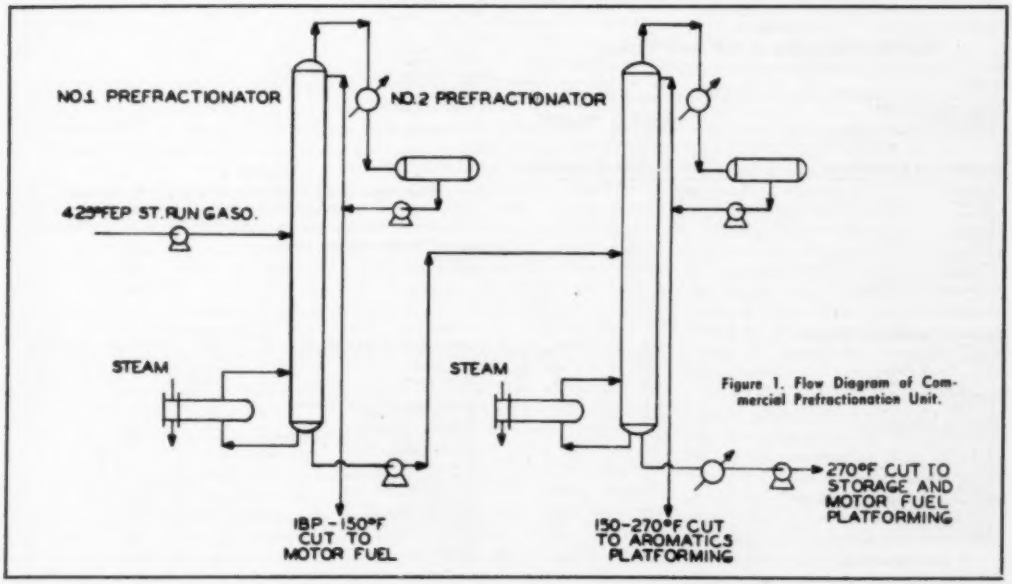


Figure 1. Flow Diagram of Commercial Prefractionation Unit.

duce the quantity of these materials required by the defense effort if the present trend toward refinery expansion continues. It also appears that these low-boiling aromatics can be produced economically in streams of very high purity without resorting to the treating procedures such as have been used in the past in producing these low-boiling aromatics from coal tar.

The production of high purity low-boiling aromatics from petroleum is normally carried out in three steps:

1) prefractionation to concentrate the naphthenes in the feed;
2) the actual conversion of the hydrocarbons, predominantly naphthenes, to aromatics; and
3) the separation and purification of the aromatics produced.

In order to illustrate the over-all economics of producing aromatics from petroleum by means of the UOP Platforming Process and the Udex extraction process, laboratory and pilot plant data were obtained utilizing two cuts obtained from a sample of Gulf Coast 425° F. straight-run gasoline.

As shown in Table 1, this gasoline had an F-1 clear octane rating of 49.8. The hydrocarbon group composition of this gasoline is given in Table 2 and shows that the 149-185° F. or nominal C_8 cut contains 47 percent naphthenes and 11 percent aromatics. The C_7 and C_8 cuts contain 49½ percent and 29½ percent naphthenes respectively. This gasoline is somewhat better than average in naphthene and aromatic contents in the C_8 and C_7 cuts, but is below average in the C_8 fraction in respect to both naphthenes and aromatics. California straight-run gasoline, on the other hand, would be somewhat higher in naphthene plus aromatic content and would of course produce higher yields of aromatics.

The gasoline was fractionated in semicommercial equipment, as shown

TABLE 1
Properties of Gulf Coast 425° F. End Point Straight-Run Gasoline

Gravity, °API	56.4
Specific Gravity	0.7531
Sulfur, Weight Percent	0.01
Reid Vapor Pressure, Lb.	7.3
Octane Ratings:	
F-1 clear	49.8
F-1+3 cc's TEL/gallon	72.2
Characterization Factor	12.00
D-86-46 Distillation:	
IBP °F.	120
50 percent	280
End point °F.	425
Percent Recovered	98.0
Percent Bottoms	1.0
Percent Loss	1.0

Composition, Liquid. Vol. Percent (Podbielniak Distillation and Mass Spectrometer):

Propane	0.8
Isobutane	1.0
n-Butane	1.8
Isopentane	2.4
n-pentane (to 115 °F.)	2.4
Hexane plus fraction	91.6
Total	100.0

TABLE 2
Hydrocarbon Group Composition of Gulf Coast 425° F. End Point Straight-Run Gasoline

	LABORATORY FRACTIONATION AND ANALYSIS						
Cut No.	1	2	3	4	5	6	
Boiling Range of Cut, °F.	IBP-115	115-149	C6 149-185	C7 185-226	C8 226-274	274+ Bottoms	Total
Composition, Vol. Percent of Full Boiling Gasoline:							
Paraffins	8.4	2.9	3.5	6.0	8.7	21.7	51.1
Naphthenes	.....	0.4	3.8	8.1	5.2	17.7	35.2
Aromatics	.....	.....	0.9	2.2	3.7	6.9	13.7
Total	8.4	3.3	8.1	16.3	17.6	46.3	100.0
Composition, Vol. Percent of Cut:							
Paraffins	100.0	88.0	42.0	37.0	49.5	47.0	51.1
Naphthenes	.....	12.0	47.0	49.5	29.5	38.0	35.2
Aromatics	.....	.....	11.0	13.5	21.0	15.0	13.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 3
Semi-Commercial Prefractionation of Gulf Coast 425° F. End Point Straight Run Gasoline

BREAKUP No.	1			2		
Yields, Vol. Percent of Gasoline Charge:						
IBP—150 °F.	.....	9.4	.....	.....	11.4	.....
150-270 °F.	.....	39.9	.....	.....	.....	.....
150-400 °F.	.....	.....	.....	.....	87.0	.....
270-400 °F.	.....	49.1	.....	.....	.....	.....
400 °F. + bottoms	.....	1.6	.....	.....	1.6	.....
Properties of Fractions:	IBP-150 °F.	150-270 °F.	270° F. + Bottoms	IBP-150 °F.	150-400 °F.	400 °F. + Bottoms
Gravity, °API	100+	58.5	48.0	91.8	52.8	39.0
Specific Gravity	.....	0.7447	0.7883	0.6337	0.7678	0.8299
Sulfur, Wt. Percent (UOP Method H-201-43)	.....	0.004	.....	.....	0.006	.....
Octane Ratings:						
F-1 Clear	.....	58.6	.....	.....	44.1	.....
F-1 + 3cc TEL/gal.	.....	79.8	.....	.....	68.8	.....
Reid Vapor Pressure, Lbs.	.....	1.9	.....	.....	1.1	.....
ASTM D 86-46 Distillation:						
IBP, °F.	.....	190	300	.....	200	450
50 Percent	.....	217	334	.....	283	462
E.P., °F.	.....	330	438	.....	414	515
Percent Bottoms	.....	1.2	1.3	.....	1.3	1.9
Percent Loss	.....	0.3	0.2	.....	0.2	0.1
Hydrocarbon Type Analysis, Vol. Percent						
Total Aromatics	.....	9.4	.....	1.4	15.2	.....
Total Paraffins	.....	48.9	.....	96.8	45.6	.....
Total Naphthenes	.....	41.7	.....	1.8	39.2	.....
Total, All Hydrocarbons	.....	100.0	.....	100.0	100.0	.....

TABLE 4
Pilot Plant Platforming of Gulf Coast Fractions

Test No.	1		2	
Charge Stock to Reactors:				
Boiling Range, °F.	150-270 °F.		150-400 °F.	
Vol. Percent of Original Gasoline	39.9		87.0	
Yields, (Based on Reactor Charge)	SCF/B	Vol. Percent	SCF/B	Vol. Percent
Hydrogen	1052		597	
Methane	12		57	
Ethane	27		82	
Propane	46		119	
Isobutane		1.8		3.3
n-Butane		2.3		5.0
Isopentane		2.9		4.8
n-Pentane		0.9		3.0
Depentanized Platformate		83.9		74.6
Total		91.8		90.7
Properties of Depentanized Platformate:				
Gravity, °API	48.9		45.6	
Specific Gravity	0.7844		0.7990	
Sulfur, Weight Percent	0.001		0.002	
UOP Vapor Pressure, Lbs.	2.5		2.0	
Octane Ratings:				
F-1 Clear	85.5		90.0	
F-1 + 3cc TEL/gal.	96.0		97.5	
ASTM D-86-46 Distillation:				
IBP °F.	178		172	
50 Percent	219		253	
EP °F.	305		439	
Percent Bottoms	1.2		1.3	
Percent Loss	0.3		0.2	
Hydrocarbon Type Analysis, Vol. Percent:				
Total Aromatics	48.8		55.6	
Total Paraffins	45.3		38.2	
Total Naphthenes	5.9		6.2	
Total, All Hydrocarbons	100.0		100.0	

TABLE 5
Pilot Plant UDEX Extraction of Typical Platformate Yields and Properties of Products

Yields, Vol. Percent of Charge to Extractor:	
Raffinate	44.2
Extract	55.8
Total	100.0

Properties of Charge and Products	Charge to Extractor	Raffinate	Extract
Gravity °API	46.5	63.7	31.1
Specific Gravity	0.7949	0.7249	0.8702
Aromatic Content (Mass Spectrometer):			
Benzene, Vol. Percent	4.5	0.1	.....
Toluene, Vol. Percent	25.0	2.7	.....
Xylene and Ethyl Benzene, Vol. Percent	24.8	9.2	.....
C_9 + Aromatics	.....	.....	.....
Total Aromatics	.....	.....	.....
Reid Vapor Pressure, Lbs.	1.8	3.0	.....
Octane Ratings:			
F-1 Clear	95.7	66.4	.....
F-1 + 3cc TEL/gal.	iso C_8+0.08	85.3	.....
ASTM D-86-46 Distillation:			
IBP °F.	173	152	.....
50 Percent	238	210	.....
EP °F.	358	394	.....

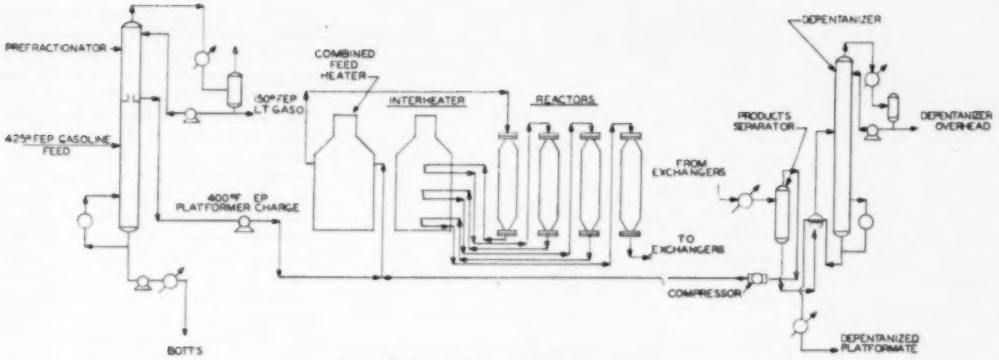


Figure 2. Flow Diagram of Platforming Unit.

in Table 3, in order to prepare feed stocks for the subsequent Platforming tests. Two breakups were made to illustrate at least two types of operations which can be carried out for producing aromatics.

In the first scheme, 9.4 percent of the gasoline was removed overhead as a 150° F. end point cut and 39.9 percent of a 150-270° F. cut containing C_6, C_7 and C_8 fractions was separated. The 270-400° F. cut representing 49.1 percent of the gasoline was removed next leaving 1.6 percent of bottoms boiling above the gasoline range. It will be noted that the 150-270° F. cut does not contain all of the C_8 fraction present in the gasoline, as indicated by the composition listed in Table 2. In this particular study, a specified yield of xylenes was required which was less than the maximum which could be obtained if all of the xylene formers were converted. This degree of fractionation corresponds approximately with the separation efficiency which would be obtained in a two-stage commercial prefractionator unit as illustrated in Figure 1. In this type of feed preparation unit, it appears that the most economical degree of separation is obtained when the prefractionation unit is designed to recover approximately 95 percent of the fractions boiling within the desired range as indicated by "true boiling" distillation in a laboratory hypercal column. Greater efficiency of prefractionation is too costly and less efficient prefractionation disproportionately increases the cost of the Platforming and extraction steps.

The 270°-400° F. cut in Breakup No. 1 would normally be further processed to improve its octane number for sale as motor fuel. The commonly accepted procedure has been to carry out a blocked-out operation, first processing the aromatic-producing fraction and alternately upgrading the motor fuel fraction. Recently, particularly in the case of smaller refiners, the question of combined operation on a 150°-400° F. cut for production of aromatic and motor fuel operation has been considered. The data given under Breakup No. 2 were obtained in order to illustrate this type of operation. In this case, it is contemplated that the degree of separation in the prefractionating step would be less efficient than that in the first scheme, particularly with regard to the lower-boiling hydrocarbons. As shown in Scheme 2, the 150° F. end point cut amounted to 11.4 percent of the gasoline charge and the charge to the Platforming unit would amount to 87.0 percent. This type of fractionation would be carried out commercially, in a single column withdrawing the 150°-400° F. fraction as a sidecut. This type of operation will, of course, eliminate the disadvantages of blocked-out operation, but the aromatic yield will be reduced due in part to loss of aromatic producers in the feed preparation step.

The conversion steps for production of aromatics were carried out by pilot plant Platforming operations as shown in Table 4. This process has been described in detail and its commercial application for motor fuel production discussed in a separate paper. A simplified flow diagram of a Platforming unit designed for aromatic production is shown in Figure 2. Four reactors and interheaters are usually used in order that optimum temperature control may be obtained for the highly endothermic reaction of converting naphthenes to aromatics. This diagram shows a prefractionator charging the full 425° F. end point gasoline as would be the case in Scheme II. The product from the Platforming reactors is depentanized before charging to the Udex extraction unit. From an inspection of the results given in Table 4 for Scheme I, it is seen that the depentanized Platformate amounts to 83.9 percent of the charge stock and contains 48.8 percent of total aromatics. As previously pointed out, the xylene and ethylbenzene contents of the Platformate are low because of the fact that all of the C_8 aromatic formers were not included in the feed to the Platforming unit. The following molar conversions of naphthenes to aromatics were obtained in this test on a once-through basis:

C_6	72%
C_7	90.7%
C_8	96.6%

Subsequent tests made on other stocks have resulted in improved conditions under which once-through molar yields markedly better than these are obtained. Further increases in benzene yield can be obtained by recycling the unconverted C_6 naphthenes.

The operation in Scheme II resulted in the production of 74.6 percent depentanized Platformate containing 55.6 percent of total aromatics. In order to minimize the size of the subsequent extraction and purification operations, this Platformate would be rerun to separate the cut containing the desired aromatics, leaving a bottoms fraction for motor fuel blending.

While actual pilot plant Udex extraction tests were not carried out on the specific Platformates produced in the above tests, sufficient data are available from pilot plant Udex operations to determine the recovery and purity of aromatics obtainable with this process.

The Udex process employs a mixture of glycol and water as a solvent for the separation by extraction of high purity aromatics from mixtures with other hydrocarbons. It was originated by The Dow Chemical Company; the engineering and licensing of the process being handled by Universal Oil Products Company.

The outstanding feature of the Udex

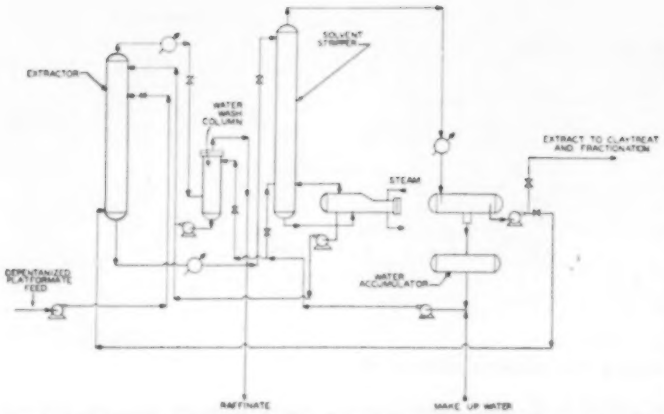


Figure 3. Flow Diagram of Udex Extraction Unit (Clay Treater and Three Fractionators Connected In Series for Separating Aromatics Not Shown).

process is its ability to handle wide boiling range stocks. Processing in preceding refinery operations and need for intermediate tankage are as a result, appreciably simplified. The fraction fed to the Udex unit can be as wide boiling as necessary to assure inclusion of all of the potential aromatics without interfering with the purity of the product, and the difficulties in fractionation resulting from nonideality of mixtures of hydrocarbon types are avoided. The fractionation to obtain benzene, toluene and mixed xylenes, each of high purity, is much easier when the separations of the individual compounds are made after removal of nonaromatics.

A simplified flow diagram of a Udex unit is shown in Figure 3. The process uses an efficient multistage countercurrent extraction column of a novel design developed especially for this purpose. Solvent is fed at the top of the column, hydrocarbon feed at an intermediate point and hydrocarbon reflux at the bottom. The rich solvent is taken to a stripper, wherein the dissolved aromatics are separated from the solvent, the latter being recirculated to the extraction column. Vapors from the stripper are condensed and separated into two phases. The water phase is used in part to wash traces of dissolved glycols from the raffinate; the remainder is returned to the stripper. The hydrocarbon phase from the stripper receiver is a mixture of aromatics from which the benzene, toluene and a mixed ethylbenzene-xylene fraction, all of high purity, are separated by distillation. Since temperatures and pressures are low and the system is non-corrosive, carbon steel equipment is used throughout the unit.

The solvent used in the Udex process possesses a number of properties which make it particularly well suited for the purpose. It has a high solubility for aromatics combined with good selectivity. Its high boiling point makes it possible to distill the dissolved aromatics from it rather than the reverse, greatly reducing utility re-

TABLE 6

Fractionation of UDEX Extract[a]

	Percent by Volume of Extract	Percent by Volume of Udex Charge
Yields:		
Prebenzene (cut 1)	0.3	0.1
Benzene (cut 2)	8.1	4.5
Toluene (cut 3)	43.0	24.0
Xylenes and ethylbenzene (cuts 4 to 12)	37.2	20.8
Co-plus-aromatics (bottoms)	11.5	6.4
Total	100.0	55.8

Properties of Products	ASTM Nitration-grade Benzene D-835-47[b]	ASTM Nitration-grade Toluene D-841-47[c]	ASTM Nitration-grade Xylene D-843-47[d]	1	2 Benzene	3 Toluene	4	5	6	7	8	9	10	11	12
Cut No.				1	2	3	4	5	6	7	8	9	10	11	12
Percent by volume of extract				0.2	8.1	43.0		0.4	12.6	9.0	5.4	6.1	1.4	1.8	0.5
Boiling range, °C.				39-78	78-95	95-120	120-136	136-137	137-138.5	138.5-139.5	139.5-140	140-140.5	140.5-143.5	143.5-144	144-145
Benzene, percent by weight					99.9										
Toluene, percent by weight						99.8									
Ethylbenzene, percent by weight								82.0	59.7	28.2	3.7				
p-Xylene, percent by weight								7.8	17.3	25.2	23.6	16.2	8.0		
m-Xylene, percent by weight								7.7	20.6	45.2	70.3	82.7	66.4	25.2	16.5
o-Xylene, percent by weight								2.5	2.4	1.4	2.4	1.1	25.6	74.8	83.5
Acid-wash color (ASTM D-848)	2 maximum	2 maximum	6 maximum		1—	1—									
ASTM Distillation (100 Ml) °C. (D-850-50):															
Initial boiling point					79.7	110.2									
End point					80.3	111.0									
Solidifying point, °C. (ASTM D-852)	4.85 minimum				5.23										
Specific gravity, 20/4	0.8820-0.8860	0.8690-0.8730	0.8650-0.8700		0.884	0.872									
Acidity (D-847-47)	No free acid			No free acid											
Color (D-853-47)	Not darker than solution of 0.003 grams per liter $K_2CR_2O_7$ in H_2O			Water white											
Sulfur compounds (D-853-47)	Free of H_2S and SO_2			Free of H_2S and SO_2											
Copper-strip corrosion (D-849-47)	No iridescence; no gray or black deposit or discoloration			Passed											

[a] Clay-treated. [b] All within 1 C, including 80.1 C. [c] All within 1 C, including 110.6 C±0.1 C; maximum paraffins, 1.5 percent by volume. [d] All within 3 C, including 139.3 C; maximum paraffins, 4.0 percent by volume.

TABLE 7

Estimated Utility Requirements

(Basis: Steam driven pumps, gas engine driven compressors.)

Scheme I

Blocked-out Aromatics-Motor Fuel Operation

	Feed B/SD	Fuel Gas MM Btu./Hr.	Circulating Water—GPM (30 °F. Rise)	Steam 275 psi Lbs./Hr.	Elec. Power, KW
Prefractionation (steam reboilers)	10,000	None	2,300	47,000	10
Platforming					
—aromatics	3,990	63	1,300	3,000	10
—motor fuel	4,910	87	2,700	8,000	
UDEX Extraction (steam reboilers)	3,350	2	4,000	85,000	10
Total		152	10,300	143,000	30

Scheme II

Combined Aromatics-Motor Fuel Operation

	Feed B/SD	Fuel Gas MM Btu./Hr.	Circulating Water—GPM (30 °F. Rise)	Steam Lbs./Hr.	Elec. Power, KW
Prefractionation	10,000	155	5,200	17,000	20
Platforming	8,700				
Rerun Column for Platformate	6,500		1,000	8,500	
UDEX Extraction (steam reboilers)	3,350	2	4,000	85,000	10
Total		157	10,200	110,500	30

TABLE 8

Estimated Investment Costs

SCHEME	I Blocked-out Aromatics-Motor Fuel Operation	II Combined Aromatics-Motor Fuel Operation
Process Equipment:		
Prefractionation	$ 750,000	$3,500,000
Platforming	3,200,000	
UDEX Extraction (including treating and after fractionation)	1,300,000	1,300,000
Total Process Equipment	5,250,000	4,800,000
Auxiliaries:*		
Steam Generation (including water treating)	500,000	400,000
Cooling Tower—12,000 GPM (including pumps, lines, etc.)	200,000	200,000
Tankage	550,000	400,000
Initial Catalyst and Solvent Charge:		
Platforming catalyst	200,000	200,000
Extraction Solvent	44,000	44,000
Clay for treating aromatics	1,000	1,000
Total Auxiliaries	$1,495,000	$1,245,000
Total Process Plus Auxiliary Equipment	$6,745,000	$6,045,000

* Other auxiliaries such as roads, buildings and lines outside process area not included.

TABLE 9

Estimated Prefractionation Operating Costs

Scheme I

Basis: Charging 10,000 B/SD of Gasoline	$/SD	Cents/Bbl. of Charge
(1) **Operating Supervision:**		
1/3 man per shift @ $3.00 per hour	24	0.2
2) **Operating Labor:**		
1/2 man per shift @ $2.75 per hour	33	0.3
(3) **Utilities:**		
Fuel gas @ 10 cents/MM Btu	none	
Cooling water @ 1 cent/M gals.x2300 GPM	33	
Electric power @ 1 cent/KWHx10 KW	2	
Steam @ 25 cents/M lbs. x 47,000 lbs./Hr.	282	
Total Utilities	317	3.2
4) **Taxes and Insurance:**		
Estimated @ 2½%/year of $750,000	54	0.5
(5) **Maintenance:**		
Estimated @ 3%/year of $750,000	65	0.7
Total	493	4.9

TABLE 10

Estimated Platforming Operating Costs

Scheme I

Basis: Charging 3,990 B/SD of 150-270 °F. or 4,910 B/SD of 270-400 °F. Naphtha in Blocked-out Operation	$/SD	Cents/Bbl. of Reactor Feed
(1) **Operating Supervision:**		
1/3 man per shift @ $3.00 per hour	24	0.3
(2) **Operating Labor:**		
1 operator per shift @ $2.75/hour	66	0.7
1 helper per shift @ $2.40/hour	58	0.7
(3) **Catalyst:**		
Estimated @ 7 cents/bbl. of reactor feed = 8,900 BSD	622	7.0
(4) **Utilities:**		
Fuel gas @ 10 cents/MM Btu 130 x MM Btu/hr	360	
Cooling water @ 1 cent/M gals. x 4,000 GPM	58	
Electric power @ 1 cent/KWHx10 KW	2	
Steam @ 25 cents/M lbs. x 11,000 lbs./Hr.	66	
Total Utilities	486	5.5
(5) **Royalty:**		
At 7.5 cents/bbl. of reactor feed x 8,900 BSD	668	7.5
(6) **Taxes and Insurance:**		
Estimated @ 2½%/yr. of $3,200,000	220	2.6
(7) **Maintenance:**		
Estimated @ 3%/yr. of $3,200,000	277	3.1
Total	$2,431	27.4

Note: Estimated operating cost for prefractionation plus Platforming, including rerunning Platformate in Scheme II is $2,614 per stream day.

quirements. The use of a two-component solvent permits adjustment of selectivity and solubility to best correspond to desirable operating conditions, and supplies volatility necessary to permit stripping at moderate temperatures and at atmospheric pressure. The low solubility of glycol in nonaromatic hydrocarbons and its high solubility in water permit clean separation of solvent from the raffinate without distillation. Since one component of the solvent is water, drying of the feed is unnecessary.

The glycol, which is the major component of the solvent, is readily available, noncorrosive, nontoxic, stable under operating conditions, relatively nonviscous at the normal operating temperature, possesses a good density difference with respect to hydrocarbons, and is moderate in cost.

In the development of the process major emphasis was placed on effecting separations with a minimum consumption of utilities. Many novel features incorporated in the design helped to accomplish this. Two which might be mentioned here are the essentially isothermal operation of the extraction column and stripper and the avoidance of any distillation from which either raffinate or glycol is taken as an overhead product.

The process has been extensively investigated in the laboratory and in pilot plant equipment. The unit has been found to be extremely flexible, easily controllable, and very stable in such operations. The pilot unit produced specification grade products with clean separations for extended periods with very little attention from the operator.

At the present time four Udex units ranging in size from 950 to 3500 barrels of charge per day have been licensed and are in various stages of design and construction.

In order to illustrate the recovery and purity of product which can be obtained by Udex extraction, the results of a pilot plant operation on a typical depentanized Platformate containing approximately 55 percent aromatics are given in Table 5. The subsequent treatment and fractionation of the Udex extract to produce the high-purity aromatics are given in Table 6. It was found that the benzene and toluene fractions separated from the Udex extract by distillation would meet all specifications for nitration grade with the exception of the acid-wash color. A clay treatment of the extract was sufficient to permit the benzene and toluene cuts to meet the acid-wash color specification. The over-all results given in Table 5 and 6 show that 99

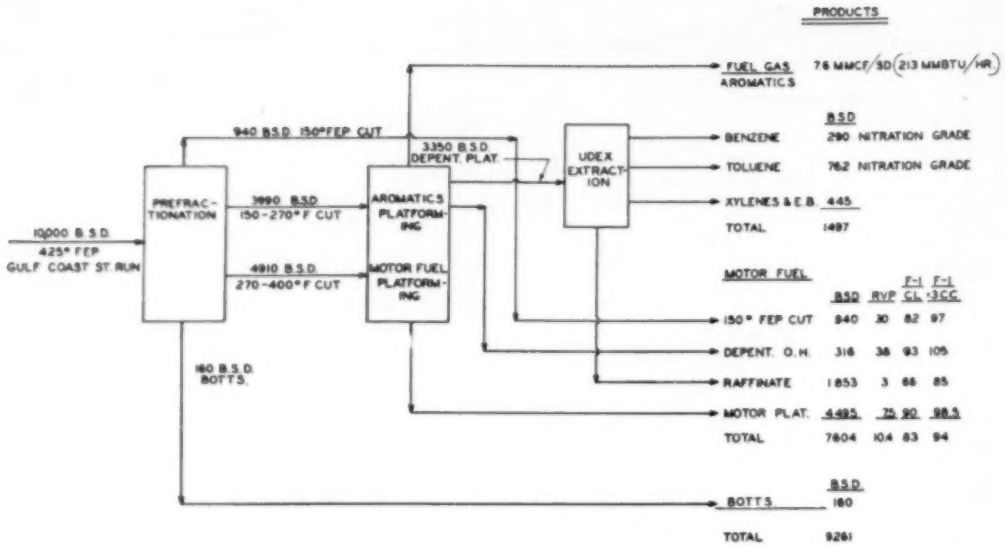


Figure 4. (Above) Production of Aromatics. Scheme I. Blocked-Out Aromatics-Motor Fuel Operation.

TABLE 11
Estimated UDEX Operating Costs

Scheme I

Basis: Charging 3,350 BSD of depentanized Platformate and producing 1,497 BSD of aromatics	$/SD	Cents/Bbl. of Charge
(1) Operating Supervision:		
1/3 man per shift @ $3.00 per hour	24	0.7
(2) Operating Labor:		
1 operator/shift @ $2.75/hour	66	2.0
1 helper/shift @ $2.40/hour	58	1.7
(3) Utilities:		
Fuel gas @ 10 cents/MM Btu x 2 MM Btu/hr.	5	
Cooling water @ 1 cent/M gals. x 4,000 GPM	58	
Electric power @ 1 cent/KWH x 10 KW	2	
Steam @ 25 cents/M lbs. x 85,000 lbs./hr.	510	
Total Utilities	575	17.2
(4) Chemicals:		
Solvent	36	1.1
Clay	90	2.7
(5) Royalty:		
290 BSD Benzene x 50 cents/gal. x 2%	122	
762 BSD Toluene x 20 cents/gal. x 2%	128	
445 BSD Xylenes x 20 cents/gal. x 2%	75	
Total	325	9.7
(6) Taxes and Insurance:		
Estimated @ 2½%/yr. of $1,300,000	94	2.8
(7) Maintenance:		
Estimated @ 3%/yr. of $1,300,000	112	3.3
Total	$1,380	41.2

Cost/gal. of aromatics is $\frac{\$1380}{1497 \times 42} = 2.2$ cents/gal.

Note: Estimated operating costs in Scheme II are $1,342/SD.

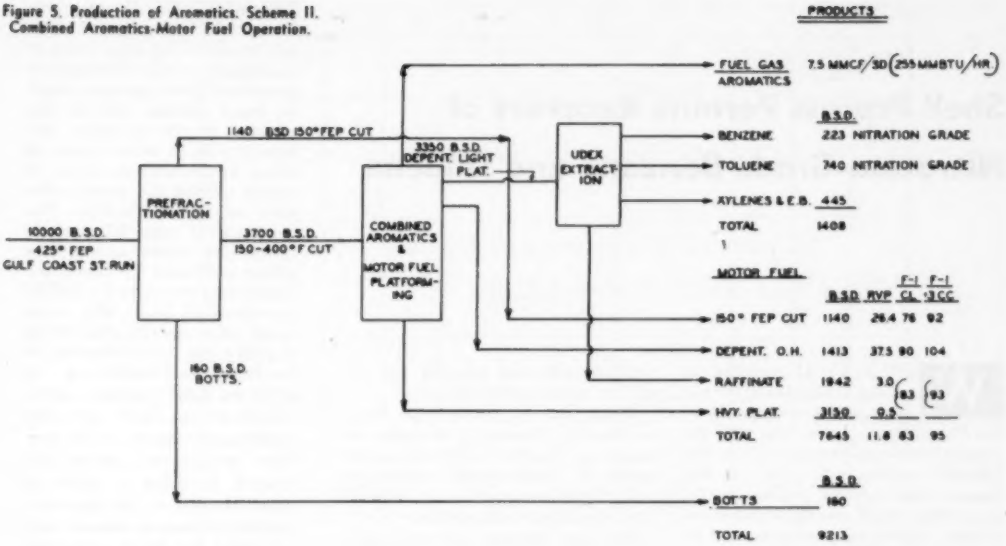
percent of the benzene in the feed to the extraction pilot plant was recovered as nitration grade benzene, 95 percent of the toluene was recovered as nitration grade toluene and 84 percent of the xylene plus ethylbenzene was recovered in a fraction containing no material other than C_8 aromatics which could be detected.

Using the pilot plant and semicommercial data discussed above, the over-all economics of the two schemes of operation were worked out on the basis of processing 10,000 barrels per stream day 425° F. end point Gulf Coast straight-run gasoline. Block flow diagrams of these operations projected from the pilot plant yield data are given in Figures 4, and 5. A comparison of these over-all yields shows that the blocked-out aromatics-motor fuel operation of Scheme I produces a slightly higher yield of aromatics and slightly less dry gas and motor fuel of the same F-1 clear octane number than the combined aromatics-motor fuel operation of Scheme II. It should be pointed out that in order to make this comparison, it was considered that the same amount of xylene and ethylbenzene (445 barrels per stream day) would be extracted in Scheme II as was extracted in the Udex unit in Scheme I. The remainder of the C_8 and heavier aromatics would be left in the motor fuel. The difference in aromatics yield between Schemes I and II, therefore, is brought about by the increased benzene and toluene yields in Scheme I.

The estimated utility requirements and investment costs for the two schemes of operation are given in Tables 7 and 8 and the estimated direct operating costs for prefractionation, Platforming and Udex extraction are given in Tables 9, 10 and 11. It will be noted that the utility and labor rates used in these calculations are approximately those corresponding with Gulf Coast area rates. Adjustments can be made in these calculations for application to other areas.

The over-all economics of the two schemes of operation are compared in Table 12. The value of the 425° F. end point Gulf Coast straight run gasoline charge stock was calculated on the basis that it is worth 10 cents per gallon as 72 octane number leaded gasoline (3 cc's TEL/gallon). On an unleaded basis, it would therefore be 9.25 cents per gallon. The value of the nitration grade benzene of the purity given in Table 6 was set at 50 cents per gallon with nitration grade toluene and the xylenes and ethylbenzene set at 20 cents per gallon. It was considered that the motor fuel would be leaded to 92 octane number premium gasoline worth 12.0 cents per gallon and that the 400° F. plus bottoms which would normally be rerun in the crude unit would be worth 8.5 cents per gallon. On this basis, it is shown that either

Figure 5. Production of Aromatics. Scheme II. Combined Aromatics-Motor Fuel Operation.



of the two schemes for producing aromatics would be very profitable. In Scheme I, involving blocked-out aromatics-motor fuel operation, the estimated investment cost of $6,745,000 would be paid out in 2.03 years before income tax and amortization charges. The somewhat lower investment of $6,045,000 in Scheme II, involving combined aromatics-motor fuel operation, would be paid out in 2.06 years on the same basis. This study also shows that the additional investment of $700,000 in Scheme I earns $380,000 more per year than does Scheme II. It appears therefore that for large installations, the blocked-out procedure described in Scheme I would be most advantageous; whereas, for smaller installations, the lower capital requirement required by the procedure followed in Scheme II, in which a combined aromatics-motor fuel operation is carried out, would also have advantages.

Conclusion

The following conclusions may be drawn from the pilot plant data and economic studies presented in this report:

1) Very high purity low-boiling aromatics can be produced economically from petroleum by the UOP Platforming and Udex extraction processes. These operations can be carried out in conjunction with the production of high quality motor fuel;
2) The question of blocked-out aromatics-motor fuel operation versus combined aromatics-motor fuel operation has been discussed and it is shown that each operation has advantages depending upon the end result desired. The blocked-out operation requires a greater investment and operating cost than the combined operation. A good return on the additional investment is obtained, however, so that this scheme should be attractive to large refiners. The pay-out time for the lower investment cost in the combined operation is only slightly greater than the pay-out time in the blocked-out case.
3) The use of UOP Platforming and Udex processes by both large and small refiners can assure the production of an adequate supply of aromatics for the defense effort and for the ever-expanding petrochemical industry.

TABLE 12
Economics of Operations
(Basis: Charging 10,000 BSD of 425° F EP Gulf Coast Straight-Run Gasoline)

			SCHEME I. Blocked-Out Aromatics—Motor Fuel		SCHEME II. Combined Aromatics—Motor Fuel	
VALUE OF PRODUCTS	Cents/Gal.	$/Bbl.	BSD	$/SD	BSD	$/SD
Benzene	50.0	21.00	290	6,090	223	4,683
Toluene	20.0	8.40	762	6,401	740	6,216
Xylenes and Ethyl Benzene	20.0	8.40	445	3,738	445	3,738
Motor Fuel 92 O.N. Premium	12.0	5.04	7,604	38,324	7,645	38,551
400 °F. + Bottoms	8.5	3.57	160	570	160	570
Total Liquids			9,261	55,123	9,213	53,758
Fuel Gas @10 cents/MM Btu.				511		612
Total Value of Products				55,634		54,370
Cost of Charge Stock:						
425 °F EP Gulf Coast St. Run (50 F-1 clear)	9.25	3.88	10,000	38,800	10,000	38,800
Operating Costs:						
Prefractionation (see Table 9)				493		2,614
Platforming (see Table 10)				2,431		
UDEX Extraction (see Table 11)				1,380		1,342
Tetraethyl Lead @0.26 cent/ml.				1,510		1,830
Maintenance @2 percent/year on auxiliary equipment				72		58
Taxes and Insurance @2½ percent/year on auxiliary equipment				90		72
Administration and overhead estimated at				500		500
Interest at 4 percent on investment				780		700
Amortization at 20 percent/year of investment				3,900		3,500
Total Operating Costs				11,156		10,616
Net earnings before income tax and amortization, $/SD				9,578		8,454
Net earnings before income tax and amortization, $/year				$3,320,000		$2,940,000
Net earnings before income tax but after deducting amortization, $/year				$1,970,000		$1,720,000
TOTAL INVESTMENT				$6,745,000		$6,045,000
Pay-out time before income tax and amortization charges, years				2.03		2.06

ACKNOWLEDGMENT

The writer wishes to acknowledge the assistance of the employes and licensees of Universal Oil Products Company and of the employes of The Dow Chemical Company who have contributed either directly or indirectly to the preparation of this paper.

Shell Process Permits Recovery of Nitration-Grade Benzene and Toluene

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THE PRODUCTION of nitration-grade benzene and toluene involves the separation of essentially a chemically-pure substance from sources which at times contain only a few percent of the aromatic admixed with a wide range of other hydrocarbons, some of which exhibit the same volatility as the aromatic. The presence of only 0.1 percent of the next higher aromatic is alone sufficient to bring the distillation range to the ASTM specification limit. The acid-wash color specification limits rigidly the concentration of certain unsaturates: e.g., as little as 0.002 percent cyclopentadiene, 0.01 percent methylpentadiene, or 0.1 percent cyclohexene can be tolerated. In order to meet all specifications for nitration-grade benzene or toluene and to allow for slight variations in feed composition and plant control, a commercial plant must be designed for 99.5 percent purity. The Shell extractive distillation process has had the benefit of 12 years' commercial experience in the recovery of nitration-grade aromatics. The application of this process to the recovery of nitration-grade benzene alone, and also to the recovery of nitration-grade benzene together with an aromatic-rich aviation gasoline blending stock, is discussed.

WORLD War II provoked intensive expansion of the toluene productive capacity of the United States. In the year 1940 the country's toluene production was 30,500,000 gallons per year[1] derived mainly from coal-tar sources. In the year 1945, which saw the war draw to a close, the toluene production had increased to 202,000,000 gallons per year,[2] with almost all of the additional amount coming from petroleum sources. Fifteen plants were completed, of which eleven used Shell extractive distillation; this represented about half of the total toluene capacity. The first commercial extractive distillation plant for aromatics recovery was placed in operation in 1940 at Shell Oil Company's Houston refinery.

The history of expansion in toluene is now being repeated with another aromatic, viz, benzene. In 1949 the production of chemical-grade plus motor-fuel-grade benzene totaled 156,000,000 gallons,[3] almost entirely from coal-tar sources. In 1951 the supply of all grades of benzene was estimated to be 250 million gallons,[4] of which about 175 million gallons were derived from coke-oven light oil and 25 million gallons from petroleum, whereas 50 million gallons were imported. The National Production Authority has certified additional capacity for 133 million gallons annually.[5]

Three recovery processes are being employed in this current aromatics expansion program: 1) extractive distillation; 2) liquid-liquid extraction using diethylene glycol-water solvent; and, 3) silica-gel adsorption.

The first benzene recovered on a commercial scale from petroleum by extractive distillation was from Shell's Wilmington refinery early in 1947, where the toluene facilities there were converted without mechanical change of any kind to production of the next lower aromatic. Three other toluene extractive distillation plants have been converted to benzene recovery, viz.: Continental Oil Company's plant at Ponca City, Okla.; Pan American Refining Company's plant at Texas City, Texas; and the plant of Standard Oil Company (Indiana) at Whiting, Ind. Besides these, three extractive distillation plants for benzene recovery are known to be under construction, viz.: Atlas Processing Company, Shreveport, La.; Standard Oil Company of California, El Segundo, Calif.; and Shell Oil Company, Houston. A list of aromatics extractive distillation plants is given in Table 1.

This Problem of Purity

The quantity production of nitration-grade aromatics from petroleum sources during and since World War II assumes special significance when one considers the high purity which "nitration-grade" implies. The production of benzene and toluene involves

Original presentation as "Shell Extractive Distillation Process for Recovery of High-Purity Aromatics" was before the 17th mid-year meeting of the American Petroleum Institute's Division of Refining, San Francisco, May 14, 1952.

TABLE 1

Extractive Distillation Units for Aromatics Recovery

COMPANY	Location	Aromatic
I. Now Operating:		
1. Continental Oil Company	Ponca City, Okla.	Benzene, toluene
2. Pan American Refining Corporation	Texas City, Texas	Benzene
3. The Pure Oil Company	Toledo, Ohio	Toluene
4. Shell Oil Company	Wilmington, Calif.	Benzene, toluene, and xylenes
5. Shell Oil Company	Wood River, Ill.	Toluene, xylenes
6. Standard Oil Company (Indiana)	Whiting, Ind.	Benzene
II. Under Construction:		
1. Atlas Oil Processing Company	Shreveport, La.	Benzene
2. Shell Oil Company	Houston	Benzene, toluene
3. Standard Oil Company of California	El Segundo, Calif.	Benzene

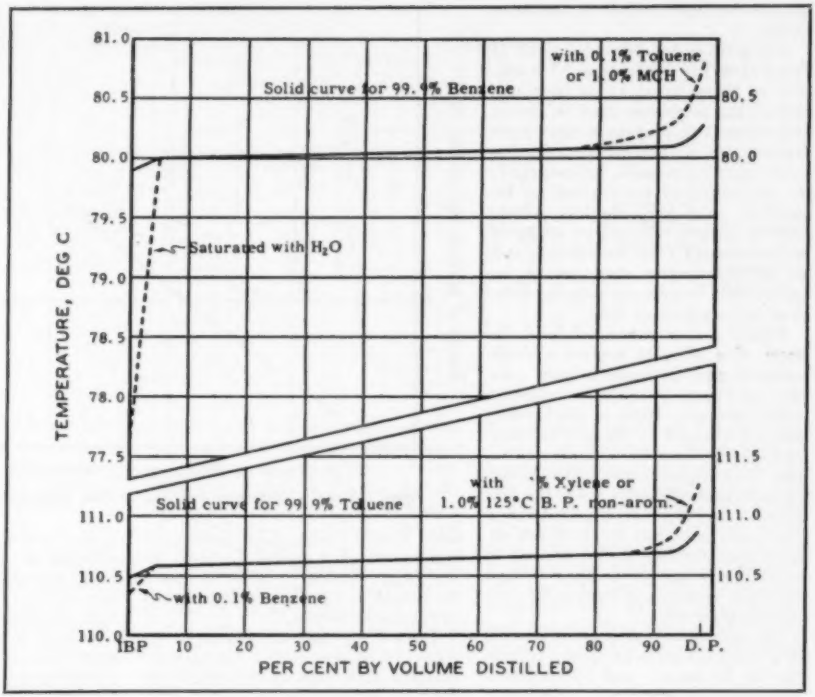
TABLE 2

Specifications for Nitration-Grade Aromatics

	Benzene ASTM D-835-50	Toluene ASTM D-841-50	Xylenes ASTM D-843-50
Specific gravity, 15.56/15.56	0.8820 to 0.8860	0.8690 to 0.8730	0.8650 to 0.8700
Distillation range: initial to dry, °C.	1.0, including 80.1	1.0, including 110.6±0.1	3.0, including 139.3‡
Solidification point, °C.	4.85°	.....	.....
Saturates, percent by weight (maximum)	.....	1.5 percent†	4.0 percent
Acid-wash color (maximum)	2	2	6
Acidity	None	Same	Same
Sulfur	No H_2S or SO_2	Same	Same
Copper corrosion	No coloration	Same	Same
Color	Not darker than 3 ppm $K_2Cr_2O_7$ in H_2O	Same	Same

* Barrett Div., Allied Chemical and Dye Corp., and others specify a minimum of 5.0 C.
† U.S. Army specifies 1.0 percent by volume.
‡ Minimum initial boiling point, 137.2 C.; maximum dry point, 140.5 C.

Figure 1.
ASTM Distillation



the separation of essentially a chemically-pure substance from sources which at times contain only a few percent of the aromatic admixed with a wide range of other hydrocarbons, some of which exhibit the same volatility as the aromatic.

High-purity, or nitration-grade, aromatics are most commonly produced to conform to the ASTM specifications summarized in Table 2. A detailed examination of a few of the most pertinent specification tests is necessary in order to obtain a clear idea of the problems involved in producing aromatics which conform to them.

The distillation range of 1.0° C., initial to dry, specified for benzene and toluene must be considered in the light of the fact that 99.9+ percent benzene or toluene has a range of 0.4 C. according to the standard procedure and that, with less pure samples, the observed initial points and dry points are not reproducible to better than ±0.1° C. Thus the safe tolerance for impurities is considerably less than one might at first surmise. The extent to which the distillation curve for 99.9 percent benzene, or toluene, is shifted by the addition of a few known impurities is shown in Figure 1. Thus the presence of only 0.1 percent of the next higher aromatic is alone sufficient to bring the boiling range to the specification limit. About 1 percent of a naphthene such as methyl cyclohexane in benzene can just be tolerated, whereas saturation with water will cause the maximum boiling-range specification to be exceeded. The initial boiling point of benzene may be lowered as much as 2.3° C. by the amount of water corresponding to saturation at room temperature.

The acid-wash test is perhaps the most sensitive of the specification tests; it detects small traces of certain types of unsaturated hydrocarbons. For example, as little as 0.002 percent cyclopentadiene, 0.01 percent methylpentadiene, or 0.1 percent cyclohexene can be tolerated for an acid-wash color Specification 2 (Table 3). It is particularly significant that these types of compounds are the most difficult hydrocarbons to separate from the aromatics by the more common physical separation techniques; e.g., adsorption, extraction, and extractive distillation.

A maximum of 1.0 percent impurity is allowed in benzene by the freezing point specification of 5.0° C. minimum (Figure 2). In the case of toluene, the ASTM specification for saturates allows 1.5 percent maximum, whereas the U.S. Army specification allows only 1.0 percent.

In summary, one finds that, in order to meet all specifications for nitration-grade benzene or toluene, the product must certainly be of 99.0 percent purity, with less than 0.1 percent of a second aromatic constituent. To allow for slight variations in feed compositions and plant control, a commercial plant must be designed for 99.5 percent purity.

The Process

The requirement of high purity, when coupled with the stipulation of high recovery from dilute sources, places a premium on process control. The purity requirement imposes a necessity for long periods of onstream operation, as little opportunity exists for blending off-specification products. The Shell extractive distillation proc-

TABLE 3

Unsaturates Content in Benzene for Acid-Wash Color 2

	Percent by Volume
Cyclopentadiene (dicyclopentadiene)	0.002
2-Methyl-1,3-pentadiene	0.01
Cyclohexene	0.1
2,4,4-Trimethyl-3-pentene	2.0
1-Heptene	3.0

ess was developed with these factors in mind.

The process has been described in detail in earlier publications.[6, 7] It consists of three steps: 1) prefractionation of the petroleum stock in one or two columns to prepare a concentrate fraction which contains a single aromatic (benzene, toluene, xylenes, etc.); 2) distillation of the fraction in the presence of a higher-boiling solvent such as phenol, followed by stripping of the aromatic from the solvent; and, 3) a mild treating step, usually required only in order to pass the stringent acid-wash color test.

Figure 3 is a simplified flow diagram of a plant to recover a single aromatic such as benzene from catalytic reformate. Depentanized naphtha —for example, from a platforming unit—is charged to the prefractionation column (usually 65 trays) to reject those constituents which cannot be separated efficiently from the aromatic in the extractive distillation step. The exact conditions to be chosen depend upon the feed stock—keeping in mind that a proper balance of load should be maintained between this and the extractive step.

The aromatic concentrate is charged at a mid-point in the extraction column (60 to 70 trays), and hydrocarbon-free solvent is introduced a number of plates above. The upper section above the solvent port is provided to "knock back" solvent so that essentially aromatic-free and solvent-free raffinate is removed as top product. The lower section of the column serves to recover the aromatic, which is separated from the solvent in the subsequent stripping column (30 trays).

A small solvent cleanup still (single-stage) is provided to reject continuously very small amounts of high-boiling reaction products of phenol and diolefins, as well as phenol and iron which otherwise would accumulate in the circulating solvent. The effect is minor when oxygen is excluded from the system by gas-blanketing accumulators and rundown tanks which handle streams which reach the extraction system. Phenol reaction products amount to less than 1 barrel per week in a plant which recovers 1,000 barrels per day of aromatic from dehydrogenation product.

It has been found by experience that corrosion of carbon steel by phenol at temperatures below 170° C. is negligible. All equipment in phenol service —including lines, columns, trays, and bubble caps—can be of carbon steel except the valve trim and the reboiler tubes and tube sheets in the extraction and stripping columns, which are normally fabricated of type 316 stainless steel. The two hot solvent pumps are constructed of a special Fe-Cr-Ni alloy (e.g., worthite). Tables 4 and 5 list corrosion rates for common metals in hot phenol service.[8]

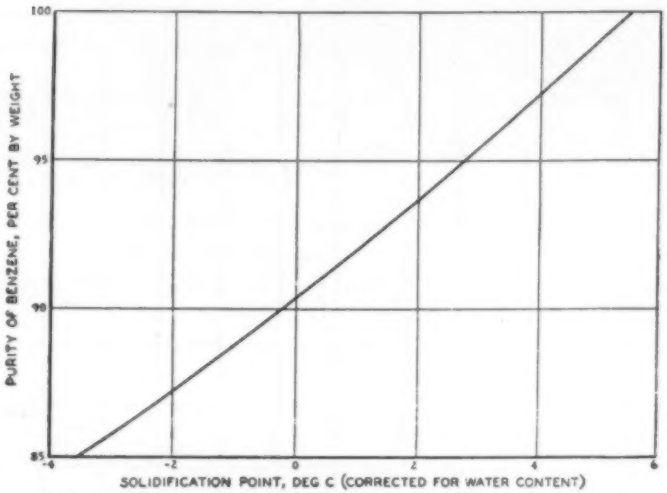


Figure 2. Purity of Benzene vs. Solidification Point (Assumes MW of Impurity = 98).

Table 6 is a material balance for recovery of benzene from a depentanized catalytic reformate which contains 46 percent benzene. The recovery of nitration-grade benzene is 98.4 percent. Utility and chemical requirements are listed in Table 7.

Why It Works

Extractive distillation depends upon the enhancement of vapor pressures in non-ideal solutions. When a dissimilar third component is added to a relatively narrow-boiling mixture of two different kinds of components, the vapor pressure of one is increased relative to that of the other, thus permitting separation by distillation. The effectiveness of phenol in aiding the separation of aromatics from close-boiling non-aromatics is illustrated by the data in Table 8. From these data it is apparent that, if one is careful to exclude the bulk of the higher-boiling non-aromatics in the prefractionation step, the close-boiling paraffins, naph-

TABLE 4

Effect of Temperature on Corrosion of Steel by Phenol

(Conditions: Polished low-carbon steel strip, 0.25 by 2 inches; immersed in 10 g of phenol dehydrated by distillation, in evacuated and sealed glass tube; stagnant for 24 hours.)

Temperature, (°C.)	Corrosion Rate (Mils Per Year)
175	1
260	16
310	30
340	46

TABLE 5

Corrosion of Different Alloys by Phenol

(Conditions: Polished metal strip, 0.25 by 2 inches; immersed in 10 g of phenol; sample dehydrated by distillation, in evacuated and sealed glass tube; stagnant for 24 hours.)

ALLOY	Corrosion Rate (From Weight Loss) (Mils Per Year)	
	Pure Phenol	Used Plant Phenol
1. Low-carbon steel (0.06 percent carbon)	30	43
2. 12-chromium steel (type 416)	24	10
3. 18-8 stainless steel (type 304)	0	0
4. 18-8 and molybdenum stainless steel (type 316)	0	1
5. Durimet stainless steel (cast)	1	0
6. 24-20 stainless steel (type 310)	1	0
7. Nickel (99.4 percent)	0	31
8. Aluminum 2-S	2,200	....

TABLE 6

Material Balance (Solvent-free Basis)

Nitration-Grade Benzene from Depentanized Catalytically Reformed C_6 Naphtha

	FEED		TOP PRODUCT		BOTTOM PRODUCT	
	Barrels Per Stream Day	Percent by Volume of Benzene	Barrels Per Stream Day	Percent by Volume of Benzene	Barrels Per Stream Day	Percent by Volume of Benzene
Benzene concentration	2,214	45.9	2,004	50.5	210	2.0
Extractive distillation	2,004	50.5	994	1.0	1,010	99.2
Solvent stripping	1,010	99.2	1,010	99.2	Solvent	
Redistillation*	1,010	99.2	1,000	99.5	10	....

* After acid treatment and caustic wash.
Note: Recovery of nitration-grade benzene = 98.4 percent.

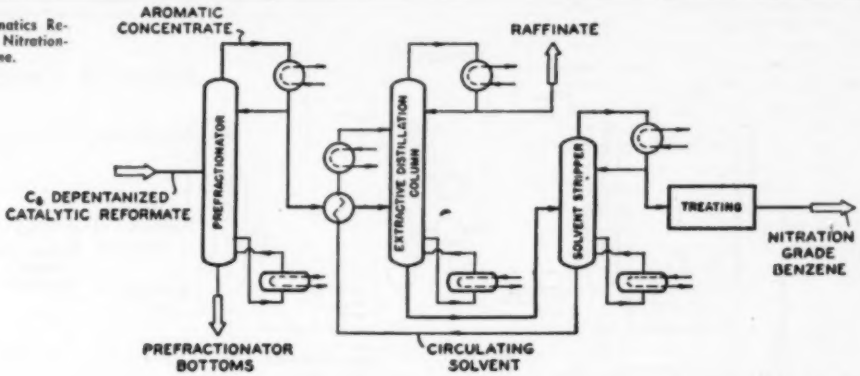


Figure 3. Shell Aromatics Recovery Process — Nitration-Grade Benzene.

thenes, and olefins, including cycloolefins, can be rejected to the overhead raffinate. This has been illustrated in a practical manner by the successful application of the process during the war for the recovery of toluene from: 1) straight-run naphthas; 2) the product from naphthene dehydrogenation at 750 psig over tungsten-nickel-sulfide catalyst; 3) hydroformates; 4) thermally reformed and cracked fractions; and, 5) cracked gasolines from the true vapor phase process. A mild pretreatment with sulfuric acid or clay in Case 4, and with phosphoric acid in Case 5, is desirable to remove part of the diolefins.

The requirement for prefractionation becomes more and more important as olefinicity increases for progressive increase in the number of double bonds makes the molecule behave more and more like an aromatic in degree of departure from ideality. This complication holds for all the common physical separation processes, viz: adsorption, extraction, and extractive distillation.

The relative volatilities given in Table 8 shows that a relatively large number of stages is required to attain high purity and high recovery. However, the excellent efficiency and capacity of vapor-liquid contacting devices make it possible to achieve these ends at reasonably low cost.

The type and severity of treatment to be given the aromatic recovered by extractive distillation depend upon the source material (Table 9). It is interesting that benzene recovered from natural gasoline requires only caustic and water wash to remove small traces of phenol, and that subsequent drying, but no redistillation, is required to meet all the nitration specifications. Nitration-grade specifications for toluene and xylenes recovered by extractive distillation from naphthene-dehydrogenation concentrate may be attained by a relatively simple treatment with maleic anhydride followed by caustic and water wash. Again, redistillation is not required. Treating losses are insignificant in these cases. As olefinicity of the concentrate increases, it becomes necessary to resort to mild sulfuric-acid treatment followed by caustic neutralization, water wash to separate polymers and subsequent distillation. Four pounds of 98-percent sulfuric acid per barrel were found to be sufficient for most toluene recovered from hydroformates. In the case of thermally cracked and thermally reformed naphthas, acid requirements increase (up to 20 pounds of 98-percent sulfuric acid per barrel of aromatic), and losses become correspondingly greater.

TABLE 7

Labor, Chemical, and Utility Requirements

For Nitration-Grade Benzene from Dependanized Catalytically Reformed C_6 Naphtha (1000 Barrels Per Stream Day of Benzene)

CHEMICALS	Per Barrel Benzene
Phenol, pound	0.2
98 percent sulfuric acid, pound	3
Caustic, pound	Less than 1
UTILITIES	
Fuel, millions of Btu's	1.1
Circulating cooling water (90 to 120° F.), gallon	3,100
Electric power, kwh	3.3
Operating labor (direct cost), cents	14.
Maintenance labor and materials, cents	10

TABLE 8

Relative Volatilities for 50-50 Molal Mixtures of Each Hydrocarbon with Benzene at 120 C

(Volatilities Relative to Benzene)

COMPONENT	Normal Boiling Point (°C)	VOLATILITY RELATIVE TO BENZENE, α	
		Solvent-free	With 55 Mol Percent Phenol
nHexane	68.74	1.28	2.33
3-Methylhexane	91.95	0.72	1.37
nHeptane	98.43	0.62	1.17
Cyclohexane	80.74	0.97	1.59
Trans-1,3-dimethylcyclopentane	92.34	0.77	1.32
Methylcyclohexane	100.93	0.60	1.00
iHexene	63.49	1.53	2.2
Cyclohexene	82.98	0.92	1.3

Can More Than One Aromatic Be Recovered?

The extractive distillation process can be used for recovery of benzene, toluene, or xylenes. One Shell plant, designed expressly for recovering toluene from dehydrogenated straight-run naphthas, periodically changes from benzene to toluene to mixed xylenes, depending upon the marketing requirements of the company. This plant has used mixed cresylic acids (200° to 220° C.) as solvent for all three aromatics. This solvent has a boiling point sufficiently high to be used for xylene recovery; however, it is not quite so selective as phenol which is recommended for both benzene and toluene recovery.

Because of the stringent requirements for purity, it is recommended that separate distillation columns be installed for each aromatic desired in nitration-grade quality. In the case of smaller-capacity units, the concentrates may be processed in blocked-out operation through a single extractive distillation section. However, it is possible rather simple to produce a single nitration-quality aromatic while an aromatic-rich concentrate is being made when the feed has a high concentration of aromatics. Figure 4 is a simplified flow sheet which illustrates the recovery of nitration-grade benzene from the stabilized product of Platforming a 60° to 110° C. (140° to

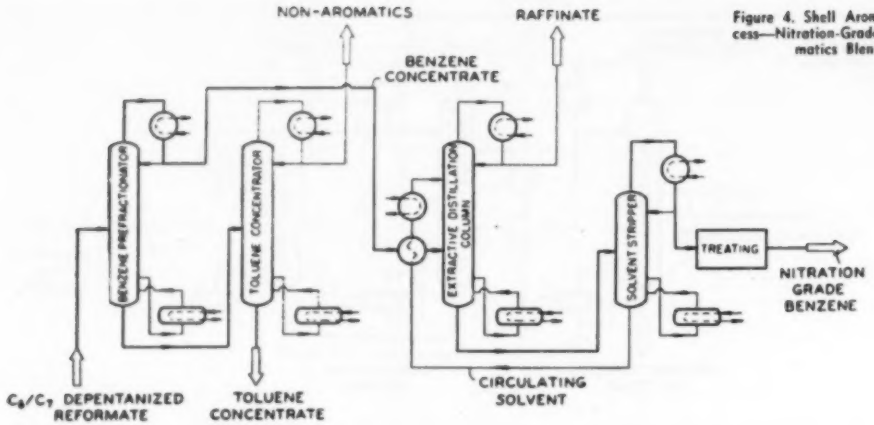


Figure 4. Shell Aromatics Recovery Process—Nitration-Grade Benzene and Aromatics Blending Stock.

230° F.) East Texas-West Texas naphtha, while simultaneously an aromatic-rich concentrate is recovered for use as a blending component in aviation gasoline (material balance, Table 10). By the addition of a column to reject non-aromatics which boil between benzene and toluene, it is possible to produce an aviation blending stock which contains about 97 percent aromatics, with an F-3 blending octane number (18-percent blend in *iso*pentane and alkylate) of 103 upon addition of 4.6 ml TEL per gallon, and an F-4 blending index number of 228 upon addition of 4.6 TEL ml per gallon. Attainment of these octane levels depends upon adjustment of the composition of the feed to the Platforming unit so as to exclude components which boil above toluene, and in the adjustment of the severity of Platforming.

Features

In summary, the following features of extractive distillation for aromatics recovery may be noted:

1) It is a process which has been proved by 12 years' commercial operating experience. Operating "bugs" have been removed through wide application. High onstream times have been realized in practice. Early achievement of onstream operation after startup can be expected.
2) High recoveries of high-purity nitration-grade aromatics have been demonstrated. The process uses well-understood techniques and well-known design methods. Tray efficiencies are well-established.
3) The process is flexible, and can be used to recover several aromatics without change of facilities and with a single solvent.
4) The process has been applied successfully to a wide range of feed materials, including thermally cracked and reformed naphthas.
5) Treating requirements and treating losses are minimized through selective removal of essentially all of the olefinic contaminants.
6) The process is continuous. Control methods are well-established, and off-specification cuts are unnecessary.
7) The equipment used in the process consists largely of distillation columns and heat exchangers which have a high salvage value in other refining applications.
8) Only minor amounts of alloy are required. Maintenance requirements have been proved to be low.

TABLE 9
Treating Requirements

Nitration-Grade Aromatic	Source	Treating Requirements	Properties	
Benzene	Natural gasoline	Caustic and water wash (redistillation not required)	Specific gravity (15.56/15.56 C.) Distillation range, deg. C. Solidifying point, deg. C. Acid-wash color	0.8842 79.8 to 80.6 5.25 0.5
Toluene	Naphthene dehydrogenation	0.01 lb. maleic anhydride per barrel of toluene, followed by caustic and water wash (redistillation not required).	Specific gravity (15.56/15.56 C.) Distillation range, deg. C. Acid-wash color Paraffin hydrocarbon, percent by vol.	0.8702 110.6 to 11.2 1.5 0.5
Xylenes	Naphthene dehydrogenation	0.07 lb. maleic anhydride per barrel of xylene, followed by caustic and water wash (redistillation not required).	Specific gravity (15.56/15.56 C.) Distillation range, deg. C. Acid-wash color Paraffin hydrocarbons, percent by vol.	0.8686 138.8 to 140.5 3.5 1.0
Toluene	Hydroforming	4 lb. H_2SO_4 (98-percent) per barrel of toluene, followed by caustic and water wash and redistillation.	Specific gravity (15.56/15.56 C.) Distillation range, deg. C. Acid-wash color Paraffin hydrocarbons, percent by vol.	0.8719 110.4 to 110.8 1 0.4
Toluene	Thermally cracked naphtha	20 lb. H_2SO_4 (98-percent) per barrel of toluene, followed by caustic and water wash and redistillation	Specific gravity (15.56/15.56 C.) Distillation range, deg. C. Acid-wash color Paraffin hydrocarbons, percent by vol.	0.8713 110.3 to 110.7 2 0.8

TABLE 10
Material Balance (Solvent-free Basis)

Nitration-Grade Benzene and Aromatic Aviation Blending Stock from Depentanized Naphtha from Platforming an East Texas-West Texas C_6-C_7 Fraction

	FEED			TOP PRODUCT			BOTTOM PRODUCT		
	Barrels Per Stream Day	Percent by Volume of Benzene	Percent by Volume of Higher Aromatics	Barrels Per Stream Day	Percent by Volume of Benzene	Percent by Volume of Higher Aromatics	Barrels Per Stream Day	Percent by Volume of Benzene	Percent by Volume of Higher Aromatics
Benzene concentration	9,000	14.2	31.0	4,554	27.5	0.02	4,446	0.6	62.7
Extractive distillation	4,554	27.5	0.02	3,321	0.9	0.00	1,233	99.2	0.1
Solvent stripping	1,233	99.2	0.1	1,233	99.2	0.1		Solvent	
Redistillation*	1,233	99.2	0.1	1,221	99.5	0.1	12	....	....
Toluene concentration	4,446	0.6	62.7	1,656	1.6	5.1	2,790	....	97.0

* After acid treatment and caustic wash.
Note: Recovery of nitration-grade benzene = 95.4 percent.

ACKNOWLEDGMENT

The authors gratefully acknowledge the efforts of the technical staffs of Shell Development Company and Shell Oil Company, upon whose work this report is based. Acknowledgment is given Messrs. W. L. Snider and A. E. Handlos for assistance in the preparation of this paper.

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The Arosorb Process In Refinery Operations

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THE AROSORB process, a Sun Oil Company development, is an outgrowth of the use of silica gel as an analytical method for separating various types of hydrocarbon liquids. Several silica-gel beds are employed in a cyclic operation involving successive adsorption and desorption steps. The desorption is effected by a suitable liquid, such as toluene or xylene, which leaves the silica gel ready for immediate re-use in the adsorption step of the next cycle.

An Arosorber is a highly flexible unit capable of handling a wide variety of refinery streams of virtually any boiling range from about 150 to 700° F. Processing several stocks permits the refiner to manufacture nitration-grade benzene and toluene, as well as a full line of high-aromatic solvents ranging from the fast- to very slow-drying types. The companion saturate streams represent a similar series of low-aromatic solvents plus a 68-cetane-number diesel blending stock.

Plant investments run from around $750,000 to $2,250,000, respectively, for nominal thruputs of 500 to 5000 bbl per day. Operating costs range from about 1 to 3 cents per gallon of charge, depending on plant size and type of charge stock.

THE Arosorb process is an outgrowth of the successful use of silica-gel adsorption as an analytical method for separating organic compounds. The analytical method was developed extensively in connection with API Research Project 6, and since then has proved to be a highly useful procedure in most petroleum laboratories. In the analytical method the gel is discarded after each test, as the relatively low cost of the gel does not warrant regeneration. In any commercial application of silica gel for selective adsorption, discarding the gel or regenerating with heat to drive out the contained hydrocarbon or organic liquid would be prohibitively expensive. However, in 1943 an idea was developed by Sun research chemists for operating a silica-gel bed in a cyclic manner. First the bed is used for adsorption, and then is desorbed with a suitable liquid, leaving the gel in condition for re-use in the next cycle. This basic idea, modified and improved over the years, has resulted in a new commercial process called the "Arosorb process."

Original presentation was before the 17th Mid-Year Meeting of the American Petroleum Institute's Division of Refining, San Francisco, May 14, 1952.

The Arosorb process actually is not merely another process, but a new refining tool in the sense that distillation, solvent extraction, and other techniques are available tools to the refiner. Although the process has been primarily developed for the separation of aromatics from various refinery streams, it can be applied to the separation of other materials such as olefins, non-hydrocrabon organic liquids, or any separation where silica gel has a selective-adsorption affinity for one or more of the component liquids in the system.

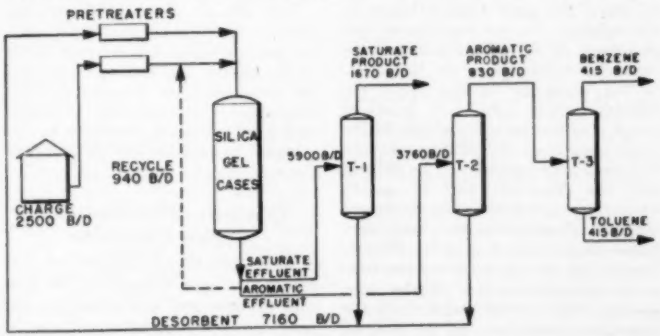
Description of Process

This discussion will show what the Arosorb process can do for a refiner and what the costs will be to obtain various results. Therefore little space can be devoted to the technical aspects of the process, but a few words along this latter line are in order.

The silica gel used is manufactured commercially by The Davison Chemical Corporation, and consists of granular particles ranging from 28 to 200-mesh. This material is used in one or more cases, or gel beds, which have diameters of 3 to 10 feet and heights of 15 to 25 feet. Inasmuch as the cycle time for a gel case runs from one to two hours, it is advisable to operate several cases suitably staggered in flow pattern in order to smooth out the overall flow of liquids through the system.

The desorbent used in any particular operation is chosen from the same chemical type as the material being selectively adsorbed from the charge stock, but has a sufficiently different boiling point to permit subsequent separation by distillation. This leads to two basic types of operation.

Figure 1. Flow Sheet of Typical Arosorber Operation, Using Desorbent Heavier than Charge.



Operation on Low-Boiling Stocks

The scheme used for relatively low-boiling charge stocks consists of employing a desorbent higher boiling than the charge. This type of operation is shown in Figure 1, which is a much simplified flow sheet of a unit charging 2500 barrels per day of catalytic reformate for the production of nitration-grade benzene and toluene. The charge stock is pre-

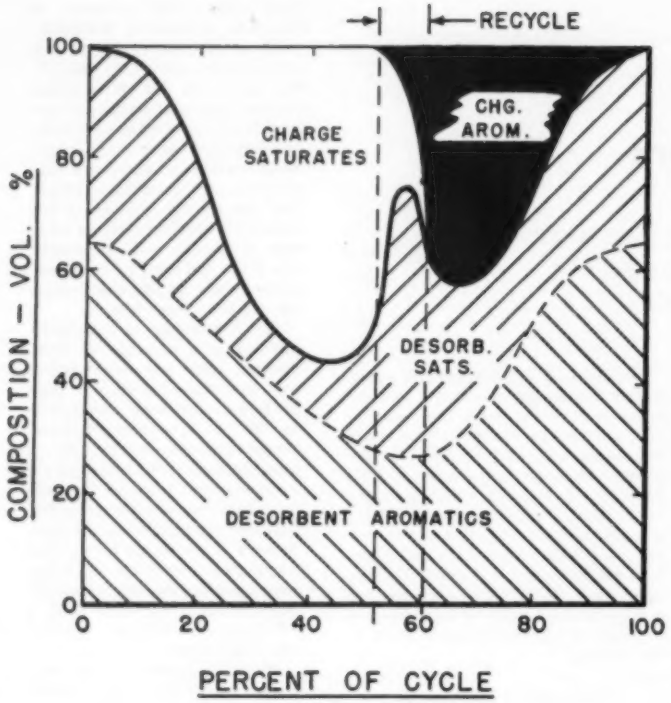


Figure 2

treated by passing it over activated alumina or other suitable material for the removal of water and other gel poisons, and then passes into one of several silica-gel cases for a period of 30 minutes. The charge is then diverted to another case, and the first case is fed with desorbent for a period of 70 minutes, at the end of which time the gel is ready to receive charge again.

In the following discussion the terms "charge saturates" and "charge aromatics" refer, respectively, to the saturates, i.e., the paraffins and naphthenes, originally present in the charge and the corresponding aromatics originally in the charge stock. As the charge stock passes down through the bed, the charge aromatics are adsorbed, leaving the bulk of the charge saturates in the voids around the gel particles. The desorbent, which consists of a crude xylene stream containing about 65 percent xylenes, pushes the saturates out of the silica-gel bed and displaces the charge aromatics adsorbed on the gel.

The effluent from the bed is divided three ways. The effluent containing the charge saturate goes to a tower, *T-1*, for recovery of the saturated product overhead and desorbent as bottoms, the latter being returned to the system for re-use. The next portion of the effluent may be recycled to the charge stream if particularly high-purity products are desired, as discussed in more detail later. The final portion of the effluent containing the charge aromatics flows to a fractionator, *T-2*, for recovery of the aromatic product as overhead and the desorbent again as bottoms. The fractionator, *T-3*, shown in the flow sheet is simply a benzene-toluene splitter.

Figure 2 is a composition diagram of the effluent from a gel case during one complete cycle. Although the overall desorbent stream contains 65 percent xylenes and 35 percent saturates of about the same boiling range as the xylenes, the composition of the desorbent in the effluent varies substantially during the cycle. Note that, at the beginning of the cycle, the effluent consists wholly of desorbent which is of normal composition. As the cycle progresses, the charge saturates become a major portion of the effluent and the desorbent part is mainly aromatics. Later in the cycle the charge saturates disappear as the charge aromatics begin to show up in the effluent. During this period the desorbent saturates are present in a higher proportion than normal, relative to the desorbent aromatics. At the end of the cycle the effluent again is wholly desorbent of normal composition.

The effluent between the two vertical dashed lines contains the only overlapping of saturate and charge aromatics, and this may be recycled to obtain maximum recovery of high-purity aromatics. The purpose of the saturate component of the desorbent is to provide the wedge of desorbent saturates between the charge aromatics and charge saturates, as shown in Figure 2, and to reduce the total aromatic content of the recycle stream.

Operation on High-Boiling Stocks

The other type of operation, shown in Figure 3, is used for relatively high-boiling charge stocks such as kerosine or catalytic gas oil. In this instance a 35:65 pentanetoluene mixture, which boils below the charge, is used as the desorbent. In addition, pentane is employed to reduce the viscosity of the charge. Choice of pentane here is merely a matter of convenience in describing the process; any low-boiling saturate fraction is suitable.

The flow sheet in Figure 3 represents the same plant discussed in connection with Figure 1, but is now shown operating on a typical charge stock in the kerosine boiling range. The kerosine plus the pentane diluent is pretreated, and flows to one of the gel cases for a period of about 80 minutes. This is followed by the desorbent for another 70 minutes to complete the cycle. The saturate and aromatic effluents again flow to fractionators *T-1* and *T-2*, respectively, but now the toluene desorbent and the pentane diluent are taken as overhead streams, leaving the saturate and aromatic products as bottoms. The pentane-toluene overhead from *T-1* is fed to *T-3*, which was the benzene-toluene splitter in the other operation, in order to recover the pentane diluent for reuse. This separation is not required on the overhead from *T-2* because pentane is a component of the desorbent.

The effluent diagram for this operation would be similar to Figure 2, the pentane diluent appearing partly in the charge saturates and partly as desorbent saturates. Recycle could be employed if desired, but extremely high-purity products normally are not required in kerosine and gasoil operations.

Character of Products from Typical Operations

Thus far the highlights of two general methods of operating the Arosorb process have been presented. The next step is to see what results can be

TABLE 1

Catalytic Reformate—Charge and Product Tests

	Arosorber Charge	Benzene	Toluene	Saturate Product
Yield, percent by volume	100.0	16.5	16.5	67.0
Chemical composition, percent by volume:				
Aromatics	35	99	99	3
Olefins	2	....	....	3
Paraffins	56	....	....	94
Naphthenes	7	....	....	....
Specific gravity, 60/60 F.	0.7360	0.8820	0.8707	0.6995
Solidifying point, °C.	....	5.10	....	....
Paraffins, percent by volume	....	....	0.6	....
ASTM Distillation:	D-86-46, °F.	D-850,°C	D-850, °C.	D-86-46, °F.
Initial boiling point	156	79.4	110.0	180
50-percent point	186	80.0	110.7	185
Dry point	220	80.3	111.0	220
Acid-wash color	....	4*	6*	....
Bromine index	....	227*	....	....
Acidity	....	No free acid	No free acid	....
Sulfur compounds	....	Negative	Negative	....
Copper-strip corrosion	....	Negative	Negative	....
F-1 octane number, without TEL addition	75.7	....	....	62

* Before finishing.

TABLE 2

200-F to 300-F Catalytic Gasoline Fraction—Charge and Product Tests.

	Arosorber Charge	Aromatic Product	Saturate Product
Yield, percent by volume	100.0	36.2	63.8
Chemical composition, percent by volume:			
Aromatics	35	92	2
Olefins	6	1	8
Naphthenes	30	4	46
Paraffins	29	3	44
Gravity, deg API at 60 °F.	47.0	32.7	55.7
ASTM distillation, °F.:			
Initial boiling point	208	232	215
10-percent point	224	251	232
50-percent point	242	266	244
90-percent point	276	288	272
End point	320	364	304
Aniline point, °F.	67.1	....	128.3
Mixed aniline point, °F.	116.2	55.7	....
Kauri butanol solvent, ml at 77 °F.	55.4	90.0	36.9
Sulfur, percent by weight	0.014	0.016	0.010
Octane No.:			
F-1, without TEL addition	83.9	....	63.1
F-1, plus 1 ml TEL per gal	....	....	74.0
Performance No.:			
F-3 plus 4.6 ml TEL per gal	....	109	....
F-4 plus 4.6 ml TEL per gal	....	195	....

TABLE 3

300-F to 400-F Naphtha Fraction—Charge and Product Tests.

	Arosorber Charge	Aromatic Product	Saturate Product
Yield, percent by volume	100.0	15.8	84.2
Chemical composition, percent by weight:			
Aromatics	17	91	1
Naphthenes	26	3	31
Paraffins	57	6	68
Gravity, deg API at 60 °F.	47.4	31.1	51.1
ASTM distillation, °F.:			
Initial boiling point	298	306	295
10-percent point	318	322	316
50-percent point	334	336	337
90-percent point	354	356	356
End point	400	400	406
Aniline point, °F.	127.0	....	150.4
Mixed aniline point, °F.	140.7	75.2	....
Kauri butanol solvent, ml at 77 °F.	38.3	88.6	32.4
Sulfur, percent by weight	0.019	0.028	0.010
Flash Point (Tagliabue closed-cup tester), °F.	102	104	103

TABLE 4

Kerosine—Charge and Product Tests.

	Arosorber Charge	Aromatic Product	Saturate Product
Yield, percent by volume	100.0	15.8	84.2
Chemical composition, percent by weight:			
Aromatics	16	91	1
Naphthenes	23	2	27
Paraffins	61	7	72
Bromine No.	0.4	1.5	0.0
Gravity, deg API at 60 °F.	43.3	24.4	47.0
ASTM distillation, °F.:			
Initial boiling point	338	340	335
10-percent point	370	374	368
50-percent point	410	414	408
90-percent point	458	465	455
End point	508	510	486
Aniline point, °F.	143.4	....	164.7
Mixed aniline point, °F.	147.6	75.2	....
Kauri butanol solvent, ml at 77 °F.	36.1	98.2	28.2
Sulfur, percent by weight	0.015	0.075	0.010
Flash point (Tagliabue closed-cup tester), °F.	125	126	124

TABLE 5

Catalytic Gas Oil—Charge and Product Tests.

	Arosorber Charge	Aromatic Product	Saturate Product
Yield, percent by volume	100.0	35.4	64.6
Chemical composition, percent by weight:			
Aromatics plus olefins	39	92	5
Naphthenes	17	3	26
Paraffins	44	5	69
Bromine No.	6.0	16.3	0.5
Gravity, deg API at 60 °F.	29.3	11.1	41.2
ASTM distillation, °F.			
Initial boiling point	422	425	420
10-percent point	484	486	483
50-percent point	511	515	508
90-percent point	562	575	559
End point	604	625	604
Aniline point, °F.	131.8	....	181.8
Mixed aniline point, °F.	138.2	72.7	....
DDT solvency, percent by wt.	....	42	....
Diesel index	39	....	75
Cetane No.	40	....	68
Pour point, °F.	+5	−25	+20
Sulfur, percent by weight	0.16	0.26	0.10
NPA color	1¾	4	1¼
Flash point (Pensky-Martens closed-cup tester), °F.	225	237	225
Saybolt Universal viscosity at 100 °F., sec.	36.4	36.2	36.5

obtained with the use of the highly flexible Arosorb process on a wide variety of stocks. The characteristics of the products which can be produced from various refinery streams are covered in the following discussion and accompanying tables.

Benzene and Toluene

Table 1 shows the nitration grades of benzene and toluene and the saturate product produced from processing a suitable cut from catalytic reformate. The charge to the Arosorber contains 35 percent of aromatics, consisting of equal amounts of benzene and toluene. The benzene and toluene products shown in Table 1 represent material recovered directly from the Arosorber without any finishing step. The two products meet nitration-grade specifications except for the acid-wash color. The acid-wash color of the benzene is reduced to less than one, and the bromine index to about four, by a comparatively light acid treatment. The toluene responds to treatment with equal ease. Incidentally, the Arosorb process rejects the bulk of any olefins present in the feed to the saturate product.

The saturate product is a light gasoline with an F-1 unleaded octane number of 62, but it also holds considerable promise as a very light paraffinic solvent.

Catalytic Gasoline

Table 2 gives similar information for processing a 200-F to 300-F catalytic gasoline fraction. The aromatic product containing 92 percent aromatics commands interest as a medium-drying aromatic solvent because of the 90 Kauri butanol solvency. This material also has an F-4 performance number of 195, upon the addition of 4.6 ml TEL per gal and, therefore, is a valuable rich-mixture aviation-gasoline blending agent. The saturate product is considerably degraded in octane number from the charge because of the removal of aromatics, but still has an F-1 rating of 74 upon the addition of 1 ml TEL per gallon.

300-F to 400-F Naphtha

Table 3 gives results from the treating of a 300 to 400-F straight-run naphtha fraction. The 88 Kauri butanol solvency of the aromatic product makes it an excellent high-solvency medium-drying solvent. The saturate product containing no olefins and only 1 percent of aromatics is of considerable interest as a stock very closely approaching an odorless solvent of the medium to slow-drying type.

Kerosine

Table 4 gives the results of processing a typical kerosine; and the products are similar to those just discussed, except for the boiling point which throws them into the slow-drying solvent type.

Catalytic Gas Oil

Table 5 covers the operation on a typical catalytic gas oil, the highest-boiling product for which data are presented. Still higher boiling products can be handled under somewhat different conditions.

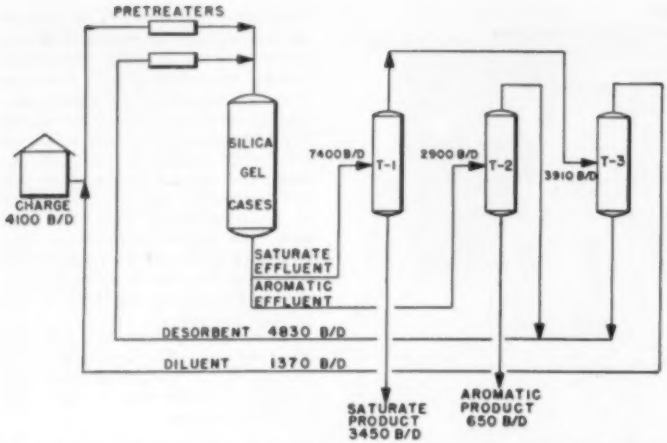


Figure 3. Flow Sheet of Typical Arosorber Operation, Using Diluent and Desorbent Lighter than Charge.

The aromatic product from catalytic gas oil may be used as a very slow-drying solvent or as an insecticide solvent. The saturate product with a 68 cetane number has application as a high-cetane diesel-fuel blending agent. One part of this material will blend with two or more parts of typical catalytic gas oil to give a 50-cetane fuel.

Desulfurization

As shown in Tables 2 to 5, sulfur compounds tend to concentrate in the aromatic product, giving saturates with sulfur contents much lower than those of the corresponding charge stocks. This point is of small importance with the low-sulfur materials used in this work, but may have real significance to the refiner who runs high-sulfur crudes.

Investment and Operating Costs

How the process operates, and what it can do for the refiner, have been developed. Now for the cost picture...

Estimated investment and operating costs for three different sizes of Arosorb units, designated I, II, and III, are presented in the following text and in Tables 6 through 9. The operating costs for these three units are also shown for three typical operations, viz., charging catalytic reformate, kerosine, and catalytic gas oil.

The three units were designated basically for charging 500, 2500, and 5000 barrels per day of catalytic reformate for the production of benzene and toluene. The thruputs were then calculated for the kerosine and catalytic gasoil operations after the removal of only obvious, small bottlenecks. As a result, the investment costs represent completely flexible plants with the indicated capacities for the several typical operations. The estimated plant investment ranges from $720,000 for the 500-barrel-per-day charging capacity to $2,260,000 for the 5000-barrels-per-day unit. These investment figures are based on an erected plant within battery limits, including silica gel and activated alumina, as well as engineering and contractor's fees.

The units have a greater capacity for kerosine than catalytic reformate which results from the low aromatic content of the kerosine, and a comparatively low distillation load per barrel of charge. The high viscosity of the catalytic gas oil requires greater dilution and this, together with the higher aromatic content, reduces throughput.

Table 6 gives the operating costs for the three units processing the catalytic reformate stock. The operating costs—which include the fixed charges for 10-year depreciation, insurances, taxes and maintenance—range from 2.3 cents per galllon of charge for the smallest plant to 0.9 for the largest plant. The unit costs for labor and utilities were based on approximate Gulf Coast figures, and the values used are given in Table 9 so as to permit converting processing costs to any other basis desired.

Table 7 covers similar information for charging kerosine. As indicated previously, the capacity of the units is appreciably increased, viz., about 60 per cent higher than for reformate; and, as a result, operating costs per gallon of charge are down to 1.5 to 0.6 cents, depending again on the size of the unit.

As shown in Table 8, the range of throughput for the catalytic gas-oil operation is 360 to 3600 barrels per day. The operating cost range is 3.4 to 1.3 cents per gallon of charge.

A running royalty figure was not included in the foregoing operating costs as it is a small item. A basis for a paid-up royalty is provided for those refiners who prefer such an arrangement.

TABLE 6

Operating Costs for Processing Catalytic Reformate.

Arosorber Unit	I		II		III	
Plant investment, millions of dollars	0.72		1.60		2.26	
Thruput, barrels per day	500		2500		5000	
Fixed charges, dollars per day:						
Depreciation, 10 years	197		438		619	
Insurance and taxes, 0.5 percent	10		22		31	
Maintenance, 5 percent	99	306	219	679	310	960
Direct charges, dollars per day:						
Labor	120		120		120	
Utilities: power	7		35		70	
fuel	17		84		168	
steam	8		37		74	
water	9		44		88	
Supplies: xylene	2		10		20	
silica gel	32		161		322	
activated alumina	3	198	12	503	24	886
Total operating cost		504		1,182		1,846
Dollars per barrel		1.01		0.47		0.37
Cents per gallon		2.35		1.12		0.88

TABLE 7

Operating Costs for Processing Kerosine.

Arosorber Unit	I		II		III	
Plant investment, millions of dollars	0.72		1.6		2.26	
Thruput, barrels per day	820		4100		8,200	
Fixed charges, dollars per day:						
Depreciation, 10 years	197		438		619	
Insurance and taxes, 0.5 percent	10		22		31	
Maintenance, 5 percent	99	306	219	679	310	960
Direct charges, dollars per day:						
Labor	120		120		120	
Utilities: power	7		35		70	
fuel	18		88		176	
steam	8		41		82	
water	9		44		88	
Supplies: isopentane	3		15		30	
toluene	2		12		24	
silica gel	32		161		322	
activated alumina	3	202	12	528	24	936
Total operating cost		508		1,207		1,896
Dollars per barrel		0.62		0.29		0.23
Cents per gallon		1.48		0.69		0.55

Diversified Operations

Particularly in the case of the larger Arosorb units, operating continuously on either kerosine or catalytic gas oil might produce too large a quantity of products compared to demand. Furthermore, many refiners would wish to process a variety of stocks in order to have a diversified line of aromatic and saturate solvents, diesel oil, etc. Advantage may then be taken of the great flexibility of the Arosorb process, which permits the refiner to select the best combination of operations to suit the market situation at any particular time. Inasmuch as Arosorbers of the type described in this paper can handle almost any type of available refinery stream (from 150° to 700° F), the number of operating combinations and the diversity of products are virtually unlimited. The problem then becomes only one of selecting the most profitable combination.

Figure 4 was prepared merely as an example to illustrate diversification, using the three charge stocks for which operating cost figures were given earlier. In Figure 4 the number of days per month for each of the three operations is given at the bottom and the amount of each product produced is shown by the vertical bars. The chart was calculated for Arosorber II, the intermediate-size unit.

The situations developed by running kerosine and catalytic gas oil each for 2.5 or 5 days per month and at the expense of catalytic reformate result in an interesting balance of products, ranging from benzene and the fastest drying aromatic and saturate solvents to the slowest drying solvents and diesel fuel. The saturate gasoline produced incidental to the manufacture of benzene and toluene was not included in Figure 4 because gasoline quantities are not normally considered in terms of gallons per year. Expressed as barrels per month, the gasoline amounts to 51,000, 42,000, 34,000, respectively, for three cases.

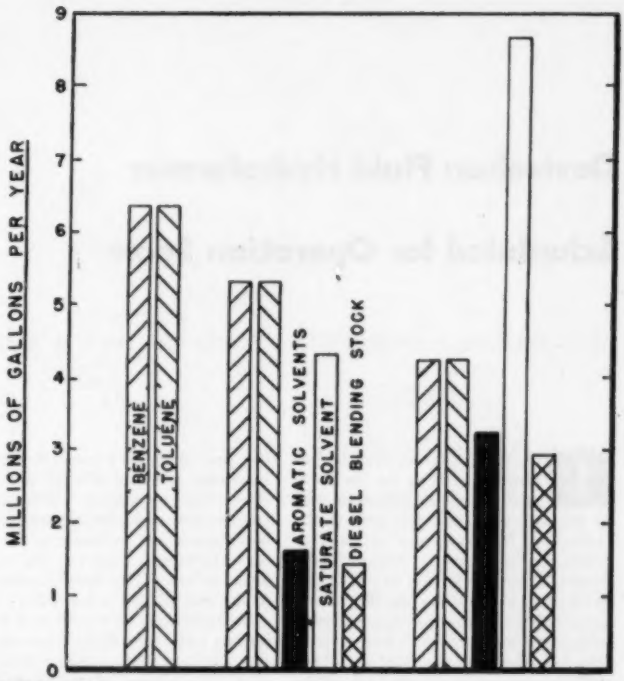


Figure 4. Diversified Operations for Arosorber II.

Of necessity, the studies outlined herein have been limited to three stocks. However, many refiners may have other streams, varying in boiling range and aromatic content, which they might wish to process. Specific proposals to suit the individual refiner's needs can readily be prepared. Universal Oil Products Company and Houdry Process Corporation, both are agents authorized to license the Arosorb process under patent rights of Sun Oil Company.

TABLE 8
Operating Costs for Processing Catalytic Gas Oil.

Arosorber Unit	I		II		III	
Plant investment, millions of dollars	0.72		1.60		2.26	
Thruput, barrels per day	360		1000		3600	
Fixed charges, dollars per day:						
Depreciation, 10 years	197		438		619	
Insurance and taxes, 0.5 percent	10		22		31	
Maintenance, 5 percent	99	306	219	679	310	960
Direct charges, dollars per day:						
Labor	120		120		120	
Utilities: power	7		35		70	
fuel	15		75		150	
steam	9		45		90	
water	8		38		76	
Supplies: isopentane	5		24		48	
toluene	10		50		100	
silican gel	32		161		322	
activated alumina	3	306	12	560	24	1000
Total operating cost		512		1239		1960
Dollars per barrel		1.42		0.69		0.54
Cents per gallon		3.38		1.64		1.29

TABLE 9
Labor and Utility Costs, Based on Gulf Coast.

Labor	2 men per shift at $2.00 per hour
Supervision	1 man for 1 shift per day at $3.00 per hour
Power	$0.005 per kilowatt-hour
Fuel	$0.12 per million Btu's (as gas)
Steam	$0.25 per 1,000 lb.
Water	$0.02 per 1,000 gal.

Universal Oil Products Company and Houdry Process Corporation, both are agents authorized to license the Arosorb process under patent rights of Sun Oil Company.

* * *

Destrehan Fluid Hydroformer

Scheduled for Operation Soon

J. E. SEEBOLD, J. W. BERTETTI, J. F. SNUGGS, and J. A. BOCK*

THE FLUID hydroformer at Destrehan will be the first commercial hydroforming unit to use the fluidized catalyst technique. It will process Gulf Coast naphtha to produce either aviation or motor-gasoline hydroformate. The unit will contact naphtha feed and hydrogen-rich recycle gas with fluid catalyst at a temperature of 930° F. and at a pressure of 250 psig; will separate the recycle gas; will stabilize the hydroformate; and will regenerate the fluid catalyst continuously at a temperature of 1100° F. and at a pressure of 260 psig. The reactor will have a diameter of 7 feet 0 inches, and will be 70 feet long; and the regenerator will have a diameter of 3 feet 0 inches, and will be 30 feet long. Catalyst will be molybdena-on-alumina, with particle-size distribution and attrition resistance similar to fluid cracking catalysts.

At a feed rate of 2000 barrels per stream day, the product will be either 87.2 percent by volume of 10-pound-Reid-vapor-pressure motor gasoline with an F-1 octane number of 95 without TEL addition, or 74 percent by volume of C_5's to 335°-F-end-point aviation fraction with an F-3 blending octane number of 97 and an F-4 blending index number of 165, both upon TEL addition. At a feed rate of 2750 barrels per stream day, the product will be 101 percent by volume of 10-pound-RVP motor gasoline with an F-1 octane number of 85 without TEL addition. The estimated operating cost for the unit at these feed rates—allowing credit for the fuel gas produced—are, respectively, 25 and 22 cents per barrel of naphtha feed.

THE first commercial hydroforming unit to use the fluidized catalyst technique will be put into operation this year at the Destrehan, La., refinery of Pan-Am Southern Corporation. Although the fixed-bed hydroforming process for producing high-octane gasoline from low-quality naphthas has enjoyed wide acceptance by the oil industry, it is only recently that the fluid catalyst technique, extensively applied in the field of catalytic cracking, has been adapted to hydroforming.

The new fluid hydroforming enjoys many advantages over the fixed-bed process. The cost of construction and operation is lower; product yield and quality are better; and operation and maintenance are simpler. These advantages result largely from the continuous nature of the process, the substantially improved catalyst temperature and activity control obtainable, the improved catalyst utilization, and the improved contacting.

The Destrehan fluid hydroforming unit is designed to process Gulf Coast naphtha for the production of high-octane aviation or motor-gasoline blending stocks.

Oil Flow

The general process flow is shown in Figure 1. Naphtha feed and recycle gas will be preheated first by exchange against hot reactor effluent and then in furnaces. Preheated feed, recycle gas, and regenerated fluid catalyst will enter the reactor near its base. Vapor will flow upward through the fluidized catalyst bed, through a catalyst-disengaging space, and then through two stages of cyclone separators. After having passed through the recycle-gas and naphtha-preheat exchangers, the reactor effluent will enter the fractionator near its base. The hydroformate, cut to the desired end point, will be taken overhead from the tower; and higher-boiling polymer will be removed from the bottom. Catalyst slurry withdrawn from the bottom of the fractionator will be returned to the reactor.

The gas and hydroformate taken overhead from the fractionator will be cooled, partly condensed, and passed into the reflux drum. Part of the gas from the reflux drum will be taken to the gas compressor to be recycled to the reactor; the remainder will flow to an absorber (not shown), where the butanes will be recovered. The liquid from the reflux drum will be charged to the stabilizer to produce a debutanized product. Design process conditions are shown in Table 1.

TABLE 1
Design Process Conditions

Reaction Conditions	
Hydroforming temperature, °F.	930
Naphtha preheat, °F.	940
Recycle-gas preheat (maximum), °F.	1,300
Pressure, psig.	250
Space velocity, pounds of naphtha per hour per pound of catalyst in the reactor	0.45
Catalyst-to-oil ratio, pounds of catalyst circulated per pound of naphtha	0.35
Recycle-gas rate, standard cubic feet per barrel of naphtha	6,000
Recycle-gas hydrogen content, mol percent	60
Regeneration Conditions	
Regeneration temperature, °F.	1,100
Pressure, psig.	260

Catalyst Flow

Regenerated catalyst will flow continuously into the reactor, where turbulent mixing with hydrocarbon vapors results in efficient contacting and uniform temperature conditions. Spent catalysts will be lifted by recycle gas through a riser into a hopper located above the reactor. Here the spent catalyst will be stripped with steam or recycle gas. Spent catalyst from the hopper will flow through a standpipe into the regenator. Regenerated catalyst will flow from the base of the regenerator through a standpipe into the reactor, completing its circuit.

Catalyst Regeneration

The catalyst will be regenerated by continuous combustion of the small amount of catalyst deposit. Com-

Original presentation as "Fluid Hydroformer at Destrehan" was to a Session on Production of Aromatics, 17th mid-year meeting of the American Petroleum Institute's Division of Refining, in the St. Francis Hotel, San Francisco, Calif., May 14, 1952.

* Seebold, Snuggs and Bock are all connected with Standard Oil Company (Indiana), Seebold at Chicago and the other two at Whiting, Ind. Bertetti is with Pan-Am southern Corporation, New Orleans.

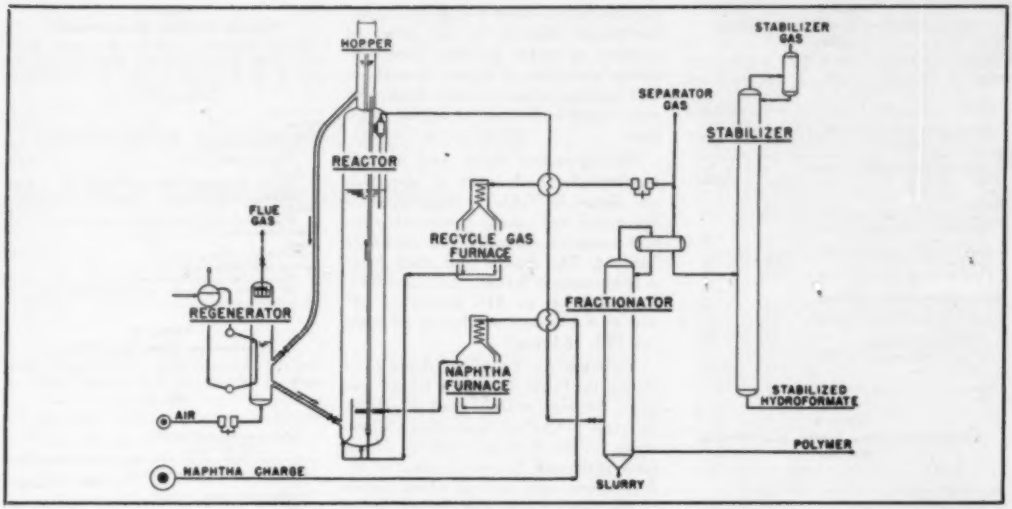


Figure 1. Fluid Hydroformer at Destrehan, La.

pressed air will enter the regenerator at its base. Surplus heat will be removed through vertical water tubes mounted inside the regenerator and partly submerged in the fluid bed of catalyst. Steam will be generated at approximately regenerator pressure so as to minimize leakage. Flue gas which leaves the top level of the fluidized bed will pass through a disengaging space in the regenerator, and then through ceramic filters to remove any entrained catalyst. Operation of the ceramic filters will be rotated so that three units will be on stream while a fourth is being blown back with hot air. The flue gas will pass through a pressure-control valve and silencer before release to the atmosphere.

Catalyst Storage

The unit will be provided with a fresh catalyst storage drum (not shown in Figure 1). An eductor system will be used for fresh catalyst unloading. Ceramic filters will be used to minimize loss of catalyst fines. Catalyst can be transferred to or from the unit while it is operating by the use of a catalyst transfer drum.

Process Control

The reactor pressure will be controlled by throttling the reactor effluent. The regenerator pressure will be controlled by throttling the flue gas. The regenerator temperature will be controlled by varying the catalyst bed level so as to change the submergence of the water tubes. The bed level in the regenerator will be controlled by the slide valve in the regenerated catalyst standpipe. The bed level in the spent catalyst hopper will be controlled by the slide valve in the spent catalyst standpipe. The pressure drop across each of these slide valves will be approximately five psi. The bed level in the reactor will be fixed by the catalyst inventory of the system. The rate of catalyst flow will be adjusted by the plug valve and the rate of gas injection used in the spent catalyst riser.

Equipment

Dimensions of the major vessels of the unit are shown in Table 2. All of these vessels will be fabricated from carbon steel. Refractory liners will be used in the reactor, regenerator, and catalyst transfer drum. The standpipes will be four-inch schedule 160 carbon-steel tubing. High-temperature furnace tubes and the transfer lines will be of alloy. Single slide valves will be used in each of the standpipes, and a plug valve of special design will be used at the bottom of the spent catalyst riser.

The plot dimensions for the unit are approximately 145 by 145 feet. The elevation at the top of the spent catalyst hopper is 125 feet.

Operating Flexibility

Allowance has been made for a high degree of operating flexibility in the design of the Destrehan unit. It will be capable of processing an unusually wide range of feed stocks, including high-boiling naphtha, mixtures of straight-run and cracked naphthas, and high-sulfur naphthas. It can produce benzene or toluene, or both by proper selection of feed stocks and operating conditions—although recovery facilities for these materials are not presently being provided. The gas-recycle rate can be varied, and sufficient overcapacity has been included in the combustion-air compressor to permit catalyst regeneration at substantially more than the design rate. The naphtha-preheat temperature can be increased from the design temperature of 940° F. to a maximum of 1050° F. The catalyst-to-oil ratio can be reduced from the design ratio of 0.35, or it can be increased to 1.0 or more. Provision has been made for the use of new and improved catalysts as they become available.

TABLE 2
Vessel Dimensions

	INSIDE DIAMETER		Length (Feet)
	Feet	Inches	
Reactor	7	0	70
Spent catalyst hopper	2	4	31
Regenerator	3	0	30
Fractionator	4	0	35
Stabilizer	3	0	58
Catalyst-storage drum	6	0	41
Catalyst-transfer drum	4	6	12

Catalyst

The catalyst to be used will be molybdena-on-alumina which contains approximately 10 percent molybdenum trioxide. The initial particle-size distribution will be about as follows:

	Percent
Finer than 20 microns	5 to 10
20 to 40 microns	Over 20
Coarser than 80 microns	Under 30

TABLE 3
Motor-Gasoline Yields and Octane Numbers

(Basis: Gasoline with a Reid vapor pressure of 10 pounds and an end point of 400° F.)

F-1 Octane Number (without TEL addition):	95	85
Naphtha-feed rate, barrels per stream day	2,000	2,750
Products:		
Gasoline yield, percent by volume	87.2	101
Extraneous butanes included, percent by volume	3.2	10
Gasoline, barrels per stream day	1,744	2,777
Dry gas, pounds per hour	2,730	1,890
Catalyst deposit, pounds per hour	110	110
Octane numbers for motor gasoline:		
F-1 (without TEL addition)	95	85
F-1 (with addition of 3.0 ml TEL per gal.)	101	96
F-2 (without TEL addition)	84	76
F-2 (with addition of 3.0 ml TEL per gal.)	90	85

TABLE 4
Aviation-Gasoline Yields and Octane Numbers

C5's to 335° F.-end-point gasoline:	
Yield, percent by volume	74
F-3 blending octane number (with addition of 4.6 ml TEL per gal.)	97
F-4 blending index number (with addition of 4.6 ml TEL per gal.)	165
7-lb.-RVP 335° F.-end-point gasoline:	
Yield (with isopentane added), percent by volume	94.6

This distribution is similar to that obtainable in commercial grades of fluid catalytic cracking catalyst. The attrition resistance of the catalyst will be equal to or better than that of the more resistant grades of synthetic fluid cracking catalyst.

Catalyst discarded from a commercial fixed-bed hydroformer will be used to start up the unit, scour it out, and provide initial operating experience. This catalyst will be subsequently replaced by fresh catalyst available from commercial suppliers.

Process Results

The Destrehan fluid hydroformer is designed primarily for high-intensity operation to produce a high-quality hydroformate suitable for use either in aviation or motor gasoline. Lower-intensity operation at higher throughput will produce a lower-quality hydroformate suitable for use in motor gasoline.

Motor-gasoline yields and octane numbers for both types of operation are shown in Table 3. Aviation-gasoline yields and octane numbers for the high-intensity operation are shown in Table 4. The design feed stock boils at temperatures between 220° a.id 335° F., and it has an API gravity of 53° and an F-1 octane number of 60 without TEL addition.

Although the catalyst deposit, as shown in Table 3, is 110 pound per hour, the regeneration load is greater in terms of carbon equivalent. Allowances for the hydrogen content of the catalyst deposit, for entrainment of hydrocarbons with catalyst which passes to the regenerator, and for oxidation of metallic constituents of the catalyst require air for combustion of 280 pounds per hour of carbon equivalent.

Operating Costs

The normal utilities requirements for high-intensity operation at a throughput of 2000 barrels per stream day are shown in Table 5. Estimated operating costs are shown in Table 6 for the high-intensity operation at low throughput, and for the alternative operation at lower intensity and higher throughput. The utilities costs are based on fuel gas at three cents per gallon of fuel-oil equivalent, and steam at 40 cents per 1000 pounds. It has been assumed that two men, with supervision, will operate the unit. Maintenance and miscellaneous costs are a fixed percentage of the investment.

As indicated in Table 6, the type of operation will influence the direct operating costs. Under high-intensity conditions the direct cost is approximately 40 cents per barrel of feed; at the lower intensity, this is reduced to 30 cents. If credit is taken for the fuel value of the dry gas produced, the utilities costs are reduced, respectively, 15 and 8 cents per barrel of feed. The resulting net costs are 25 cents per barrel of feed for the high-intensity operation, and 22 cents for the lower intensity.

TABLE 5
Normal Utilities Requirements

(Basis: Gasoline with a Reid vapor pressure of 10 pounds, an end point of 400° F., and an F-1 octane number of 95 without TEL addition.)

Steam	
Consumed:	
400-psig. pounds per hour	4,400
125-psig. pounds per hour	2,650
Produced:	
250-psig (98-percent-quality), pounds per hour	3,250
30-psig, pounds per hour	2,650
Cooling water:	
90° F. supply (30° F. rise), gallons per minute	1,680
Boiler feed water, gallons per minute	7
Power:	
Drives and lighting, kilowatts	130
Fuel gas (fuel-oil equivalent):	
Furnaces, barrels per stream day	160
Air and gas compressors, barrels per stream day	30

TABLE 6
Estimated Operating Costs

(Basis: Gasoline with a Reid vapor pressure of 10 pounds, and an end point of 400° F.)

F-1 Octane Number (without TEL addition):	95	85
Naphtha feed rate, barrels per stream day	2,000	2,750
Operating costs, cents per barrel of feed:		
Utilities	15	12
Catalyst	5	4
Labor	8	6
Maintenance and miscellaneous	12	8
	40	30
Fuel-gas credit	15	8
Net	25	22

ACKNOWLEDGMENT

The authors wish to express their appreciation for the cooperation and assistance of The M. W. Kellogg Company, New York, in connection with the preparation of this report. The Kellogg Company did the basic pilot-plant work on the Destrehan feed stock; designed and engineered the unit; and has also done the construction work.

* * *

Details of TCR—

Thermofor Catalytic Reforming Reaches Commercial Stage

J. W. PAYNE, L. P. EVANS, E. V. BERGSTROM, and V. O. BOWLES*

THE THERMOFOR Catalytic Reforming (TCR) process is used to upgrade low octane-number stocks into premium fuels in the F-1 Octane-number range of 100. Using a chromia-alumina gel catalyst this regenerative moving-bed process contains a single pressure reactor. Butane yields are low and almost complete sulfur removal is effected.

The process has been proven by three years of intensive pilot-plant study and has been engineered for commercial applications ranging up to a capacity of 20,000 barrels per day. Four commercial TCR units, with a total capacity of 50,000 barrels per day are planned for immediate installation.

PART of the progress made in automotive-engine design during recent years has been founded on the ability of the petroleum industry to produce gasolines of progressively higher anti-knock quality level. Except during World War II octane numbers have increased steadily over a considerable period of time, at the rate of 1 to 1½ units per year, to the current average level of about 84 F-1 octane number for regular-grade and about 91 F-1 for premium-grade gasolines. The demand for still higher octane numbers seems destined to continue, with increased emphasis being placed on high-compression engine design. If the trend continues to the 12:1 compression-ratio level, the octane-number requirement may be in the F-1 range of 98 to 100.

This poses an important challenge for the petroleum refining industry: It means that more drastic and efficient processing techniques must be adopted to attain these high anti-knock quality levels. Present octane-number levels are being met largely by catalytic cracking, supplemented by thermal reforming and cracking, and by catalytic polymerization.

The relative quantity and quality of gasoline components supplied by these operations at present are approximately as shown in Table A.

Although some minor increase in present octane-number levels could be effected by more extensive use of catalytic cracking and catalytic polymerization, there are obvious limitations to this course. The most effective method of attaining the substantial increase required would be to upgrade the low octane-number components of straight-run and cracked gasolines. This requires a more selective process than the widely used thermal reforming process which gives excessive yields of gas and tar when high octane-number levels are attained by reforming. The answer to the problem is catalytic reforming.

In anticipation of this trend, Socony-Vacuum has for several years been carrying on experimental work which has culminated in the development of the Thermofor catalytic reforming (TCR) process. This work involved both catalyst research and process development—first through various types of bench-scale studies and, finally, on a 50-barrel-per-day pilot-plant scale. The entire development program was conducted at Socony-Vacuum's research and development laboratories, Paulsboro, N. J.

Table A

	Percent	F-1 Octane Number (With Addition of 3 Ml TEL Per Gal.)
Catalytic gasoline	31	98
Thermal gasolines	26	89
Straight-run naphtha (including natural)	33	84
Heavy straight-run naphtha	8	68
Catalytic polymer gasoline	2	115
	100	89 pool octane number

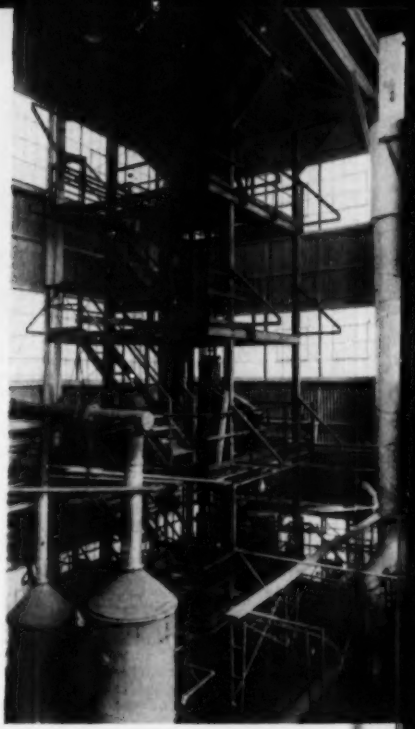


Figure 4. View of 50-barrel-per-day TCR pilot plant during construction. Furnaces in foreground. Reactor located within structure between second and fourth platforms, with small rectangular kiln and blower at right above second platform.

The TCR process employs a synthetic chromia-alumina bead catalyst which circulates through a moving-bed system comprising a reactor and a kiln; thus provision is made for continuous reaction, with regeneration of the catalyst. As implied by the term "Thermofor," the design of this system embodies many of the principles applied successfully in the well-known TCC (Thermofor catalytic cracking) process over the past 10 years.[1, 2]

Preliminary announcements of the TCR process were made last year at the Third World Petroleum Congress,[3] and recently in the press. Here will be reviewed briefly the development work which led to the process, including performance data on various stocks, and to describe in more detail the process design for commercial installation.

Development Program

Catalyst

Various types of catalyst are known to be selective for the reforming of petroleum naphthas. Of these, the one finally selected for development spe-

Original presentation as "Thermofor Catalytic Reforming (TCR)" was before the 17th Mid-Year Meeting of the American Petroleum Institute's Division of Refining at San Francisco, May 14, 1952.

*Payne and Evans are with Socony-Vacuum Laboratories, Paulsboro, N. J., Bergstrom and Bowles are with Socony-Vacuum Oil Company, Inc., New York.

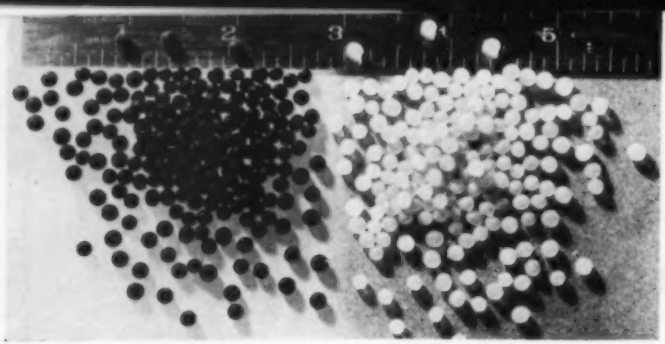


Figure 1. Chromia-alumina bead reforming catalyst, left, shown in comparison with TCC bead cracking catalyst, right.

cifically for the TCR process is a synthetic chromia-alumina gel. This type of catalyst has many desirable characteristics:

1) It has a "high octane-number ceiling"; i.e., it permits reforming to high antiknock quality (F-1 100 octane number, or higher, upon the addition of 3 ml TEL per gallon) with good yields.
2) It operates with low hydrogen partial pressure.
3) It can be readily regenerated. This can be accomplished by burning off the coke deposits. Thus wide latitude is provided for the reforming of all types of stocks, particularly the high coke-forming thermally-cracked stocks, as well as broad boiling-range straight-run stocks.
4) It promotes excellent desulfurization, and the sulfur is eliminated mainly as hydrogen sulfide in the reforming gas —thus avoiding a potential air-pollution problem.
5) Finally, the catalyst is in bead form, and it possesses the high physical strength and ruggedness of the widely used TCC bead cracking catalyst (Figure 1).

A more detailed discussion of these and other characteristics of the chromia-alumina gel reforming catalyst is given in a recent paper by Hughes et al.[4]

This catalyst has regeneration characteristics of marked significance in commercial application; e.g., it can be regenerated at a much lower temperature than cracking catalyst. All of the coke burns to carbon dioxide. The catalyst does not exhibit any significant oxidation-reduction phenomena. No appreciable amounts of sulfur dioxide are discharged with the flue gas for the reason that the sulfur is largely eliminated in the reactor rather than in the regenerator.

Bench-Scale Studies

The next important development step involved investigation of the catalyst in bench-scale units so as to obtain accurate yield–octane-number data on representative types of stocks under a wide variety of processing conditions. These data provided a basis for determining whether the process was economically attractive for further development.

Two types of bench-scale units were employed in this work. One was an isothermal fixed-bed unit with a 700-ml reactor immersed in a lead bath (Figure 2). Initially this unit was operated with hydrogen addition from cylinders. Subsequently it was modified to include a gas-recycle pump so that actual recycling of hydrogen-rich process gas could be studied. The second unit was similar to the first, except that its reactor had a catalyst capacity of 2000 ml, and it was designed to operate essentially adiabatically—thus making possible a study of heat effects during reaction and regeneration under various types of operating conditions.

The major process variables covered in this bench-scale study were pressure, gas-recycle ratio, reaction temperature, space velocity, and catalyst-to-naphtha ratio. The effect of these variables is discussed hereinafter:

a) Pressure: Reaction pressures covered a range from atmospheric to 500 psig. When reforming proceeds to a given octane number, lower pressures result in a more satisfactory yield of 10-pound-Reid-vapor-pressure gasoline and a higher hydrogen and coke production. Bench-scale data indicate the desirable pressure range to be between 100 and 200 psig—the level within that range depending on the stock and depth of reforming.

b) Gas-recycle ratio: Gas-recycle ratios up to 12 mols of gas per mol of naphtha have been explored. As the recycle ratio is increased, coke "make" decreases appreciably and gasoline yield increases slightly, whereas the hydrogen content of the recycle gas remains fairly constant. In adiabatic operation gas recycle also aids in supplying reaction heat. Practical recycle ratios appear to be in the range of three to nine.

c) Temperature: After other process conditions are fixed, reactor temperature is the principal variable for controlling the reforming severity and octane number of the product. The temperature severity required depends on the stock, and it can *range* from about 950° F. on an easily reformed stock to 1000° F. for a refractive-type stock for reforming to an F-1 octane-number level of 100 upon the addition of 3 ml TEL per gal.

d) Space velocity: As a means of controlling severity, space velocity is interchangeable with temperature over a fairly wide range; i.e., lower temperatures can be used with lower space velocities in order to produce the same yield—octane-number result. A space velocity of about 0.7 volume of naphtha per unit reactor volume per hour is satisfactory for the temperature range indicated previously.

e) Catalyst-to-naphtha ratio: Catalyst-to-naphtha ratio can be varied over a wide range, with no marked effect on product yields and quality, provided coke concentration on the catalyst does not become excessive. Because coke deposition with this catalyst is relatively low, it is possible to operate with very low catalyst-circulation rates compared to those used in catalytic cracking.

f) Yield—octane-number relationship for various stocks: A summary of representative yield—octane-number data obtained on various stocks in this bench-scale program was included in the paper by Hughes et al.[4] It was shown that the yield—octane-number relationship of the various naphthas correlates well with the conventional characterization factor *K*.

50-Barrel-Per-Day Pilot Plant

In view of the promising results obtained in the catalyst development and bench-scale investigations, extensive engineering and economic studies were made for the purpose of appraising the commercial potentialities of the process. These studies led to the third and final phase of the development program, viz., the construction and operation of a 50-barrel-per-day moving-bed pilot plant. This unit was erected almost three years ago in order to prove the important operating features of the process, and in order to provide information for the design of commercial units. The following is a brief description of the 50-barrel-per-day program:

Equipment

The reactor is a stainless-steel vessel, with an inside diameter of 12 inches; it is 15 feet high, and is designed to operate at pressures up to 500 psig. It is mounted inside of a 24-inch-diameter carbon-steel jacket. The 6-inch annular space between the two shells is filled with insulation so as to make the reactor essentially adiabatic. Vapor inlet and outlet manifolds are arranged so that the reactor can be operated with downward, upward, or split flow of the vapor stream. For catalyst flow, pressure pots

and plug valves are provided above and below the reactor.

The kiln is an atmospheric vessel designed to simulate multi-zone regeneration of the catalyst. A skip-hoist system is provided for transfer of the catalyst between reactor and kiln. The entire structure around the reactor and kiln is about 55 feet high.

Two gas-fired furnaces are used for separate preheating of the naphtha and recycle-gas streams. The two preheated streams are mixed just before they enter the reactor.

The product-recovery system is designed to permit study of various possible processing schemes. Equipment includes a knockout pot in which the reaction vapors are quenched so as to condense a heavy polymer cut, a water cooler and gas separator, an absorption system for the study of hydrogen enrichment, and a product-stabilizer tower.

A flow diagram of the 50-barrel-per-day unit is shown in Figure 3. Figure 4 (page 117) is a photograph of the unit taken during the latter stages of construction.

Stock Evaluations

Ten different types of stocks have been processed in the 50-barrel-per-day pilot plant. One of these stocks, viz., a 200° to 380° F. end-point straight-run naphtha from Tibu Petrolea (Colombia) crude, was available in large quantity at Socony-Vacuum's Paulsboro refinery; therefore, it was used for "shakedown" operations and for extensive study of process variables. The other stocks, obtained from several other refineries in tank-car quantities, represent potential charge stocks for TCR units being considered at those plants. These stocks included both straight-run naphthas and blends thereof with thermal gasolines—these stocks boiling chiefly in the 200° to 400° F. range. One stock, which comprises approximately equal parts of straight-run and high-sulfur coker naphthas from Wilmington, Calif., crude, required reforming for sulfur removal as well as for octane-number improvement. All stocks were selected from normal refinery operations, and no special precautions were used to obtain clean fractionation.

Figure 2. Bench Scale Isothermal Units (700 cc) used in evaluating catalysts and stocks for TCR reforming. Twin units located at opposite ends of common panel board.

Table 1 summarizes the properties of five of these stocks, and Table 2 gives actual pilot-plant data for reforming them under commercial design conditions to octane-number levels in the F-1 range of 96 to 100 upon the addition of 3 ml TEL per gal. It will be noted, in the case of the Wilmington blend, that excellent desulfurization and anti-knock quality improvement are obtained, with a high product yield.

Because of the large scale of the pilot-plant operation, it was obviously possible to prepare adequate quantities of products for extensive performance tests. As shown in Table 2, the pilot-plant gasolines have a moderate olefin content, and they require only a small amount of inhibitor—up to three pounds per 1000 barrels—for acceptable stability. Hughes et al.[4] have already reported results of engine tests which show that finished TCR gasolines have an acceptable engine-cleanliness rating, and that they give road anti-knock performance consistent with laboratory ratings of other gasolines in the same range.

The characteristics of the products obtained from the operation of the 50-barrel-per-day pilot plant were essentially the same as those obtained from bench-scale operations. Also, the study of process variables in the 50-barrel-per-day unit confirmed the pattern established in the bench-scale units.

Water Elimination

It was found, in the course of the pilot-plant program, that the presence of moisture in substantial concentration in the reaction zone has an ad-

TABLE 1

Properties of Charge Stocks Used in 50-Bbl-Per-Day TCR Reforming Runs in Table 2

	Tibu-Petrolea (Colombia) Paraffinic Naphtha	Mixed Texas Naphthas	Depentanized West Texas Naphtha	California (Wilmington) Naphtha	Blend of 54 Percent Straight-run Naphtha and 46 Percent Coker Naphtha from Wilmington Crude
Gravity, deg. API	54.6	56.8	57.6	45.9	46.3
Norwood bromine No.	0.9	3.0	1.7	1.0	36.7
Olefins, percent by volume	0.7	2.2	1.1	0.8	30.3
Aromatics, percent by volume	11.3	8.8	15.9	16.0	14.7
Sulfur, percent by weight	0.032	0.084	0.17	0.15	0.59
F-1 Octane Numbers:					
Without TEL addition	33.0	50.8	61.2	55.0	65.2
With addition of 3 ml TEL per gal.	60.6	68.4	75.2	71.5	75.4
ASTM Distillation, in °F.					
Initial boiling point	177	128	166	166	225
10-percent point	265	198	189	264	266
50-percent point	298	268	212	338	314
90-percent point	337	338	257	380	368
End point	380	384	295	401	400

TABLE 2

Typical Yields on TCR Reforming of Various Stocks in 50-Bbl-Per-Day Pilot Plant

CHARGE STOCK	Tibu-Petrolea Naphtha	Mixed Texas Naphthas	West Texas Naphtha	California Straight-run Naphtha	California Straight-run and Coker Blend
Reforming Conditions:					
Pressure, psig.	175	175	175	175	175
Space velocity, volumes of naphtha per hour per volume of catalyst in the reactor	0.88	0.72	0.70	0.50	0.80
Average reactor temperature, °F.	986	982	969	985	955
Recycle gas to naphtha, mol ratio	6.0	9.4	6.4	9.0	5.9
Hydrogen in recycle gas, mol percent	50	60	67	49	50
Recycle-gas furnace outlet, °F.	1,090	1,070	1,070	1,050	987
Naphtha-furnace outlet, °F.	1,030	1,019	1,013	1,050	987
Yields Based on Charge:					
10-lb. RVP reformate, percent by volume	82.0	87.2	96.1	85.4	94.0
Outside C_4 required, percent by volume	—1.0	0.6	6.4	2.7	6.1
C_5+ reformate, percent by volume	83.0	86.6	89.7	82.7	87.9
Total C_5, percent by volume	8.6	7.9	4.6	4.8	3.6
Total C_4, percent by volume	8.4	7.5	3.9	6.5	4.7
C_3 and lighter, percent by weight	10.1	12.1	8.6	14.5	10.0
Coke, percent by weight	0.7	0.3	0.2	1.5	1.4
H_2 production, cubic feet per barrel	376	414	365	430	247
Properties of C_5+ Reformate:					
Gravity, deg. API	53.2	55.4	55.4	44.4	46.6
Norwood bromine No.	9.5	9.8	8.2	17.4	13.5
Aromatics, percent by volume	44.0	34.6	35.6	65.5	33.1
Sulfur, percent by weight	0.007	.....	0.010	0.013	0.015
F-1 Octane Numbers on 10-Pound RVP Reformate:					
Without TEL addition	91.1	87.0	85.4	94.9	89.3
With addition of 3 ml TEL per gal.	99.1	97.1	96.5	101.4	97.9

verse effect on product yields. In order to avoid excessive moisture in this part of the system, provision was made for drying the recycle-gas stream. Adsorbed moisture or oxygen on the regenerated catalyst is automatically removed before it enters the reaction zone in the split-flow reactor arrangement.

Catalyst Valves

As noted previously, a pressure-lock system is used to introduce regenerated catalyst into the reactor. Operating experience in the 50-barrel-per-day unit—supplemented by extensive valve-wear studies under commercial design conditions through 15,000 operating cycles—has shown that lubricated plug valves with stellited surfaces perform satisfactorily. Such valves give excellent tight service for many months, with negligible wear or scoring of the seats and plugs.

Catalyst Life

One important objective of the 50-barrel-per-day pilot-plant program was to study catalyst-life characteristics. This refers to the ability of the catalyst to sustain activity and selectivity, as well as physical strength, in prolonged TCR service.

Bench-scale aging tests had indicated that the catalyst activity decreased only to the extent of a 3-percent drop in gasoline yield in equilibrating through repeated reforming-regeneration cycles. This has been confirmed in the 50-barrel-per-day pilot plant, wherein one batch of catalyst has been in service for about 18 months. Despite the extreme types of operation to which this catalyst has been subjected in that period, its activity loss has been equivalent to as little as 2 percent lower gasoline yield than fresh catalyst at the F-1 octane-number level of 98 upon the addition of 3 ml TEL per gallon. In this connection, the yields shown in Table 2 were obtained on an aged catalyst.

With regard to physical stability, no particular problem is anticipated with this catalyst in commercial operation.

Hydrogen Enrichment

Operations with hydrogen enrichment of the recycle gas showed no measurable advantage. Consequently it is not planned to provide for hydrogen enrichment in the commercial design.

Polymer Removal

On most reformed stocks it is necessary to provide for the removal of about 1 percent polymer in order to insure a satisfactory gum test on the motor-gasoline product. This can be accomplished either in a separate rerun tower, into which the stabilizer bottoms are flashed, or by the employment of a "knockout" pot in which a polymer cut can be taken ahead of the primary condenser. The knockout-pot system was tested successfully in the 50-barrel-per-day unit. The polymer consists almost entirely of aromatics which boil in the range of 400° to 700° F.

Reforming for Aviation-Gasoline Base-Stock Production

Although the foregoing summary deals entirely with reforming for motor-gasoline production, the process is, of course, equally adaptable for the production of highly aromatic aviation-gasoline base stocks. The preferred

TABLE 3

TCR Reforming for Aviation-Gasoline Blending

CHARGE STOCK	West Texas Straight-run Naphtha	California Straight-run Naphtha
Gravity, deg. API	54.1	54.7
Boiling range, °F.	212 to 299	302 to 312
F-1 octane number, unleaded	60	68
Reforming Conditions:		
Pressure, psig.	175	175
Space velocity, volumes of naphtha per hour per volume of catalyst in the reactor	0.35	0.35
Average reactor temperature, °F.	973	1,023
Gas-recycle ratio	12	12
Yields:		
Pre-aviation cut (C_5 to 200 °F.-end-point), percent by volume	35.2	29.7
Aviation-blend stock (200 to 300 °F.), percent by volume	42.3	32.4
Post-aviation cut (300 °F.-end-point plus), percent by volume	5.0	6.6
C_3 and lighter, percent by weight	15.0	24.9
Coke, percent by weight	0.4	2.0
7-Pound RVP Aviation Stock:*		
Yield, percent by volume of charge	63.0	48.4
Aviation-blending octane number (F-3) with addition of 4.6 ml TEL per gal.	99.5	98
Supercharge index number (F-4) with addition of 4.6 ml TEL per gal.	160	177

* Pressured with isopentane.

TABLE 4

Gasoline Blends for 30,000-Barrels-Per-Day Mid Continent Refinery

GASOLINE COMPONENT	TCR		THERMAL REFORMING	
	Barrels Per Calendar Day	F-1 Octane Number Upon Addition of 3 Ml TEL Per Gal.	Barrels Per Calendar Day	F-1 Octane Number Upon Addition of 3 Ml TEL Per Gal.
225 °F.-end-point straight-run gasoline	.....	.....	3,296	89.0
280 °F.-end-point straight-run gasoline	5,459	84.6	.....	.....
TCC gasoline	6,362	98.0	6,362	98.0
Catalytic polymer gasoline	984	106.0	1,310	106.0
Coker gasoline	814	77.5	814	77.5
TCR gasoline	2,978	98.3	.....	.....
Thermally reformed gasoline	.....	.....	4,198	87.5
Total	16,597	93.1	15,980	93.0
TEL addition for 92.0 F-1 octane-number motor gasoline, ml per gal.	2.2		2.2	

TABLE 5

Product Distribution for 30,000-Bbl-Per-Day Mid Continent Refinery

PRODUCT	TCR		THERMAL REFORMING	
	Percent By Volume	Barrels Per Calendar Day	Percent By Volume	Barrels Per Calendar Day
Motor gasoline	55.3	16,597	53.3	15,980
Kerosine	14.1	4,230	14.1	4,230
No. 2 fuel oil	18.9	5,676	18.9	5,676
No. 6 fuel oil—sales	2.5	733	3.7	1,101
Coke, tons	.....	(141)	.....	(141)
Total sales	90.8	27,236	90.0	26,987
Refinery fuel gas	7.0	2,096	7.9	2,387
Refinery fuel oil	0.5	150	.....	.....
Loss	1.7	518	2.1	626
Total production	100.0	30,000	100.0	30,000

TABLE 6

Economics for 30,000-Barrels-Per-Day Mid Continent Refinery

PRODUCTION VALUE	Price (Dollars per Barrel)	TCR (Barrels Per Calendar Day)	Thermal Reforming (Barrels Per Calendar Day)	INCREMENTAL	
				(Barrels Per Calendar Day)	(Dollars Per Calendar Day)
92 research octane-number motor gasoline	5.04	16,597	15,980	617	3,110
No. 6 fuel oil—sales	1.75	733	1,101	(368)	(644)
Refinery fuel	1.75	2,246	2,387	(141)	(247)
Loss	.....	518	626	(108)	.....
					2,219

COSTS—INCREMENTAL	TCR (Dollars Per Calendar Day)	Thermal Reforming (Dollars Per Calendar Day)	Incremental (Dollars Per Calendar Day)
TEL (total gasoline)	3,528	3,397	131
Labor and burden	260	180	80
Maintenance and shops	460	267	193
Fuel (includes steam and water)	466	713	(247)
Power	71	103	(32)
Chemical and catalyst	56	54	2
Laboratory	13	10	3
Supplies and miscellaneous	5	2	3
Taxes and insurance	78	53	25
			16
Earnings: TCR over thermal reforming and catalytic polymerization			2,059
Investment—incremental			$1,040,000
Payout, years			1.4

Note: Figures in parenthesis are negative.

charge stocks for such operation are the straight-run gasoline fractions which boil in the 200° to 300° F. range, particularly those which contain substantial amounts of naphthenes from which light aromatics are formed. Naphthenic crudes are obviously a better source of such naphthas than paraffinic crudes.

The reforming conditions required for the processing of such stocks for aviation gasoline are somewhat more severe than those necessary for motor-gasoline operation. In a unit designed for motor-gasoline reforming the added severity can be obtained by operation at the maximum temperature and at a somewhat reduced throughput rate—all other conditions remaining constant.

Several reforming runs of this type have been made on representative stocks in the 50-barrel-per-day unit. Data on West Texas and Wilmington naphthas are shown in Table 3. The West Texas naphtha yielded 42 percent by volume of an aviation blending stock which, when pressured with *iso*pentane to a Reid vapor pressure of 7 pounds, had an F-3 blending octane number of 99.5 and an F-4 index number of 160 upon the addition of 4.6 ml TEL per gallon. The California naphtha yielded 32 percent of aviation base stock which, with 4.6 ml TEL per gallon, had an F-3 blending octane number of 98 and an F-4 index number of 177. Aviation reforming operations can be used equally well to produce reformates rich in specific aromatics such as benzene, toluene, or xylenes.

Process and Mechanical Design of Commercial Units

Operating Conditions

Extensive process design and economic studies based on the pilot-plant program demonstrated that the optimum operating conditions are largely independent of feed-stock properties. The final result of these studies led to the selection of a single reactor, without reheat, which employs gas recycle in the amount of approximately 6 mols of recycle gas per mol of naphtha, with operation at a pressure of about 175 psig and at a space velocity of 0.7. Average reactor temperature may range up to 1000° F. for reforming to an F-1 octane number of 100 upon the addition of 3 ml TEL per gallon.

Flow Plan

A schematic flow diagram for a commercial TCR unit is illustrated in Figure 5. Starting with the reactor, the effluent therefrom flows through heat exchange, with recycle gas and naphtha, to a final condenser. The condensate and gas are then separated in a receiver which operates approximately at a pressure of 140 psig and a temperature of 100° F. The gas from this receiver is compressed to approximately 210 psig by the recycle-gas compressor. The condensate is pumped up to the same pressure, after which both are recontacted and cooled before they flow to the recycle separator. The condensate from the recycle separator is pumped to a depropanizer or to other suitable stabilization facilities.

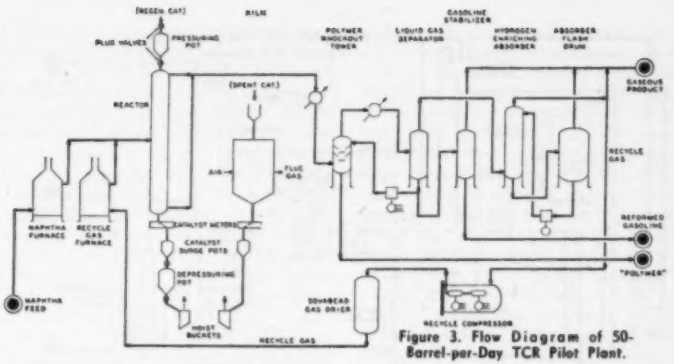


Figure 3. Flow Diagram of 50-Barrel-per-Day TCR Pilot Plant.

The net gas production flows to an absorber, and thence to the fuel line. Naphtha charge is pumped over the absorber, in order to obtain the desired recovery of light hydrocarbons from this gas; and it is pumped from the base of this absorber through heat exchange, thence through the naphtha heater which raises the temperature to approximately 900° F., and finally into the reactor. The recycle gas, which is the main stream to leave the recycle separator, passes first through a dryer, next through heat exchange with the reactor effluent, and finally through the recycle heater which heats this material to a temperature of approximately 1150° to 1200° F. The hot recycle gas mixes with the heated naphthas just before both enter the reactor.

Catalyst flows downward through the reactor in a compact moving bed. Inasmuch as the catalyst flow is comparatively small, ranging from approximately 5 to 50 tons per hour for units which have throughputs up to 20,000 barrels per stream day, it may be transported from the base of the reactor to the top of the regenerator with bucket elevators or with other suitable lift equipment. The regenerator is a conventional multi-zone type of Thermofor kiln, similar in operating principle to those installed on TCC units.[1, 2, 5] This type of kiln is well-suited to the low catalyst-circulation requirements of the TCR process, and it does not embody any new or unusual design features.

Catalytic Section

The catalytic section of TCR units is very similar in general arrangement to the catalytic section of the smaller-size bucket-elevator type TCC units, a number of which have been built in the 3000 to 5000-barrel-per-day range.[5] Just as in these TCC units, the TCR catalytic section is arranged with the reactor and kiln side by side. Auxiliaries to the reactor-kiln system include a hot catalyst storage bin for holding the catalyst during a shutdown, a fresh catalyst bin, and an elutriator for removing fines from a continuous catalyst slip stream.

The TCR kiln operates at substantially atmospheric pressure. A kiln for a 15,000-barrel-per-day TCR unit would normally be designed to burn about 2000 pounds of coke per hour, with a catalyst circulation of approximately 25 tons per hour. Regeneration is accomplished in several burning stages, with cooling between stages. Inasmuch as TCR catalyst burns quite rapidly, the average regeneration temperature is maintained in the range of 800° to 1000° F., which is approximately 200° F. lower than the comparable temperatures in a TCC kiln. Control of burning is accomplished mainly by regulation of the combustion-air temperature to the various zones. Secondary control is provided by regulation of the cooling coils between burning zones. Just as in TCC units, the cooling coils serve for steam generation.

The reactor for a 15,000-barrel-per-day TCR unit is approximately 11 feet in diameter, and it is designed to operate at a pressure of 175 psig. The naphtha and recycle-gas feed enter the center of the reactor and flow upward and downward to suitable vapor-disengaging sections. The two vapor streams which leave the reactor are combined before they enter the heat-exchange system.

The commercial reactor is provided with the same type of pressure-lock system as is used for the introduction of catalyst in the 50-barrel-per-day

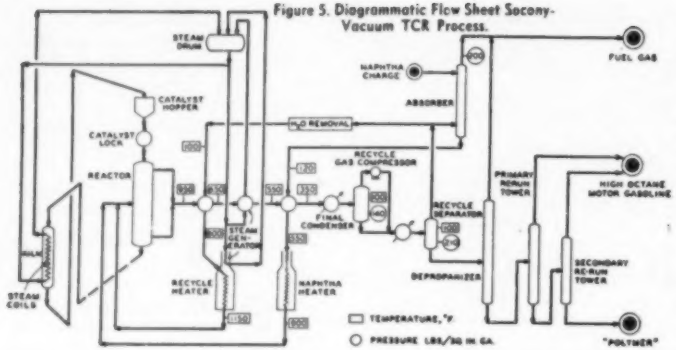


Figure 5. Diagrammatic Flow Sheet Socony-Vacuum TCR Process.

unit. The operations of filling, pressuring, emptying, and depressuring are controlled by a cycle timer which operates on a 10-minute cycle. The valves are 8-inch plug cocks which are equipped with stellited plugs and seats with special lubrication grooving; they are of the same design as those used in the 50-barrel-per-day unit.

Spent catalyst is purged in the bottom of the reactor; and, after it has left the reactor, it is transferred to a bucket elevator. In Figure 5 this transfer system is purposely shown in diagrammatic form for the reason that alternate designs are under consideration and because no specific information can be given at this time.

Heat Exchange and Heat Recovery

Inasmuch as the heat content of the reactor effluent is large, an efficient heat-exchange system is essential to the economical functioning of the process. Fortunately the reactor effluent material is very stable, and it is possible to heat-exchange this stream directly without quenching. This insures the maximum availability of high-temperature level heat to the extent that approximately 60 percent of the total heat removed from the reactor effluent serves to preheat the reactor input materials, and an additional 10 percent is used to generate steam. In the design of the heat-exchange system, particular attention must be paid to the economics of pressure drop, because any pressure drop in the reactor effluent or in the recycle exchanger must be supplied by the recycle-gas compressor.

Fired Heaters

In order to avoid thermal cracking in the naphtha heater, the outlet temperature is limited to 900° F. maximum, and the furnace is designed for a high heat input rate to the tubes near the outlet in order to reduce time temperature effects.

Although the recycle gas contains about 1 percent of pentane and heavier hydrocarbons, it is estimated that no significant cracking of this material will occur at temperatures below 1200° F. Nevertheless, as an extra precaution, the recycle-gas heater is designed to minimize cracking. In addition, this heater is designed for a low pressure drop, viz., 15 psi, in order to maintain compression requirements at a minimum. Inasmuch as the recycle gas enters this heater at a comparatively high temperature (approximately 800° F.), only radiant surface is used. For heat economy, the convection section of this heater is designed as a steam-generating unit and is tied in with the same steam drum which serves the kiln. This combination of features maintains the amount of surface required for heating the recycle gas to a minimum, and thus makes it possible to achieve a low pressure drop while thermal cracking effects are reduced to a minimum. The total heat absorbed by the recycle gas and naphtha in the heat-exchange system exceeds that absorbed in the furnaces by about 20 percent.

Compression

The total pressure drop through a TCR system which operates at a pressure of 175 psig reactor pressure is approximately 70 psi. For this condition, typical pressures at several points in the system are as follows: recycle-gas compressor, 210 psig; reactor inlet, 185 psig; reactor outlet, 175 psig; and recycle-gas compressor suction, 140 psig. Because the recycle gas is circulated in large quantities, and because it has a low molecular weight, this system offers an ideal application for a centrifugal gas compressor. It is proposed, therefore, in plants with a capacity of 2000 barrels per stream day, or higher, to install a single centrifugal recycle-gas compressor which will be driven by a condensing turbine.

Absorption and Stabilization

The product stabilizer is essentially a depropanizer, from which C_4+ reformate is withdrawn as bottoms. Normally the overhead from this unit would flow to fuel gas—although, if desired, some condensate could be recovered therefrom as liquefied petroleum gas (LPG).

The absorber operates at a pressure of 200 psig, and it is designed to recover substantially all of the pentane and heavier components and about 90 percent of the butanes from the "off" gas. Although this recovery arrangement necessitates the recycling of a small amount of C_4+ material back through the reaction system, it has been established that this design is more economical than an independent absorption and stripping system.

Polymer Removal

On some light stocks, the stabilizer bottoms can be used for motor-gasoline blending without further processing other than caustic washing. However, when naphthas of 400° F. end point, or higher, are charged, or when naphthas which contain substantial percentages of cracked materials are charged, it is anticipated that the gasoline will contain about one percent of polymer which should be separated. To accomplish this separation with a minimum loss of gasoline, it is proposed to provide a two-stage gasoline rerunning system. The first stage will flash overhead a substantial percentage of gasoline which contains no polymer; the second stage will make a sharp separation between polymer and gasoline of the desired end point. In the event it becomes necessary to produce aviation blending stocks, this two-tower arrangement will be satisfactory for the preparation of a sharply fractionated high-quality aromatic aviation blending stock. Reboiler heat for these operations may be supplied with fired reboilers or, alternatively, with a recirculating hot-oil system.

An alternate method of polymer removal—one which proved satisfactory in the 50-barrel-per-day pilot plant—involves the use of a polymer knockout tower immediately ahead of the final condenser. This tower is operated at just below the dew point of the system, which is approximately 300° F. Gasoline from the recycle separator is used for tower reflux so as to control the heat balance and the amount of polymer removal.

Water Removal

The 50-barrel-per-day pilot-plant studies emphasized the need for dehydrating the recycle-gas stream. An investigation of various drying methods showed that satisfactory drying can be obtained by means of refrig-

eration, solid desiccant, or liquid desiccant. Although solid desiccant is the most effective for the reduction of moisture content to extremely low levels, the liquid-desiccant scheme is adequate for this application.

Numerous factors are important in an appraisal of the economics of catalytic reforming. It does not matter whether a catalytic reformer is installed in an old or a new refinery; to give optimum economic results, it must be properly integrated with other process facilities. Similarly, the properties of the crude oil processed and the octane-number target have an important bearing on the economics for a particular installation.

For purposes of illustration in the present case, a typical medium-sized modern refinery for the processing of 30,000 barrels per day of Mid-Continent pipe-line crude is used as a basis for comparing the economics of installing thermal vs. catalytic reforming equipment. It is assumed that existing distillation, catalytic cracking, delayed coking, and catalytic polymerization facilities are adequate for the production of present gasoline octane-number requirements, but that reforming is necessary to provide an F-1 92 pool octane number in order to meet future competition. With this pool octane number, it will be possible to maintain a reasonable balance between the production of 95+ octane-number premium-grade, as well as lower octane-number housebrand, gasolines.

The catalytic reforming and gasoline-blending calculations are based on the use of a TCR unit to reform 3600 barrels per stream day of 260 to 410° F. boiling range [41.4 F-1 unleaded; 64.2 F-1 upon the addition of 3 ml TEL per gallon] virgin naphtha for the production of a reformate with an F-1 octane number of 98 upon the addition of 3 ml TEL per gallon. Reformer charge stock is prepared on the crude distillation unit while a 280°-F.-end-point straight-run gasoline with an F-1 octane number of 84.6, upon the addition of 3 ml TEL per gallon is taken overhead. For comparison, it has been determined that a 5700-barrel-per-stream-day thermal reforming unit would be required for the same target octane number. In this case a 5500-barrel-per-stream-day naphtha refractionator would be required to provide a 200 to 380°-F. boiling-range naphtha charge for thermal reforming—leaving a 225°-F.-end-point light straight-run gasoline for blending. It is advantageous in this case to expand an existing 1000-barrel-per-stream-day catalytic polymerization unit to 1300 barrels per stream day (catalytic polymer gasoline) in order to utilize butylenes and propylenes produced from expanded thermal reforming.

The cost of the projected TCR facilities—including a 3600-barrel-per-stream-day TCR unit, paid-up royalty therefor, and all off-site requirements—is estimated to be approximately $3.1 million. On the other hand, the cost of equipment for the thermal reforming case—including a new 5700-barrel-per-stream thermal reforming unit, a naphtha refractionator, additional catalytic polymerization capacity, as well as the paid-up royalty therefor, and associated off-site equipment—is estimated at $2.060,000.

Gasoline blends and product distributions for the alternate plans are presented in Tables 4 and 5.

The evaluation shown in Table 6 indicates, for this particular situation, net earnings for the TCR installation—over and above those of the thermal reforming and catalytic polymerization—of approximately $2000 per day. On the basis of an incremental investment of $1,040,000, a payout of 1.4 years is indicated. If it were assumed, in this refinery, that thermal cracking facilities were available for re-activation and conversion into a thermal reformer of the required capacity, then it might be possible to decrease the investment requirement for the thermal reforming case by approximately 50 percent. In this case the differential investment would be $2,070,000, and the payout approximately 2.75 years.

Some interesting conclusions can be drawn from the data presented in Tables 5 and 6, which reflect the use of a 3600-barrel-per-stream-day TCR unit vs. a 5700-barrel-per-stream-day thermal reformer, plus naphtha refractionation and incremental catalytic polymerization, to reach the target octane number:

a) Gasoline yield is increased almost 4 percent for the same octane number by the use of TCR. This additional gasoline is produced at the expense of heavy fuel, fuel gas, and volumetric loss.

b) In the case of a refinery which produces light products only, fuel-gas production may be excessive when intensive thermal reforming is employed to reach a high anti-knock quality target. Unless LPG or petrochemical utilization is considered, this excess gas would ordinarily be flared—particularly during summer months, when low vapor-pressure gasoline is made. This uneconomic situation may be avoided by the use of catalytic reforming which, in effect, converts fuel gas and loss to high-quality gasoline.

c) Total fuel requirements, including steam and water, are approximately 50 percent higher for thermal reforming than for TCR. Power requirements are about 40 percent higher.

d) Chemical and catalyst costs are almost identical for the two processes. Incremental catalytic polymerization with thermal reforming has a moderate catalyst requirement which offsets TCR catalyst cost.

Although the preceding economics are valid for a refinery situation which requires the manufacture of a comparatively low proportion of F-1 95+ octane-number premium-grade gasoline, some attention should be given to the facilities required for the production of 35 to 45 percent high-quality premium gasoline in terms of total motor gasoline. In this case it is generally not possible to meet over-all quality requirements by intensive thermal reforming plus catalytic polymerization, and the refinery must turn to catalytic reforming. Economic justification of catalytic reforming in such a situation may be established by considering the losses in revenue incurred by failure to install catalytic reforming facilities. These losses may include those associated with limited or no production of premium-grade gasoline or distress sales of excess straight-run naphtha at low prices. Although it is difficult to establish accurate values for these factors even for a specific case, the general statement can be made that a TCR unit evaluated in this manner would show payout times in the range of one to three years, which is roughly equivalent to the result shown in Table 6.

Commercial Program

Now that novel features about the catalyst, the process, and the design of the plant have been proved by extensive bench-scale pilot-plant and semi-commercial plant programs, full-scale commercial programs can be undertaken with confidence. As of this writing, the construction programs have already been announced for four commercial TCR units with a total capacity of 50,000 barrels per day. Also the industry has been advised of the construction program for a commercial TCR catalyst manufacturing plant. Much of the engineering of these commercial plants proceeded concurrently with the later stages of the 50-barrel-per-day semi-commercial plant program, so that now the engineering designs for these plants are complete.

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What Can Be Done to Combat Corrosion of Refinery Tank Roofs?

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IN RECENT YEARS The Atlantic Refining Company has been required to expend at its Philadelphia refinery in excess of $1 million per year for the repairs of steel refinery tanks. A major portion of these expenditures has been consumed by the replacement of steel tank roofs which had been destroyed by internal corrosion. To combat this costly corrosive attack, a study was made of various materials which could prolong the serviceable life of refinery tank roofs. The results of this study are herewith reported.

AT THE Philadelphia refinery of The Atlantic Refining Company the cost of repairs of steel refinery tanks in recent years has been in excess of $1 million per year. A major portion of these expenditures has been consumed by the replacement of steel tank roofs which had been destroyed by internal corrosion. This costly corrosive attack may be largely attributed to the increased amount of high-sulfur crude run (approximately 40 percent of the refinery capacity of 120,000 barrels per day). In general, Atlantic's experience has been much the same as has been reported in industrywide surveys by other companies[1a, 2, 3] which have shown that steel tanks in sour-crude service have a roof life varying from 3 to 12 years, with 8 years as the average; whereas similar tanks in sour-distillate service have a roof life from 4 to 14 years, with 7 years as the average.

Consideration was, therefore, given to the use of protective coatings, alloyed installations, and heavier-gauge steel plate as a means of combating this internal corrosion and, consequently, eliminating or reducing the frequency of roof replacements. However, the introduction of these alternate methods for tank-roof protection and replacement would involve initially higher costs than continued use of unprotected 3/16-inch steel plate.

The purpose of this paper is to evaluate the additional expenditures incurred for each of the alternate types of protection or replacement material under consideration, and to compare these costs with those of the usual steel roof replacement in such a manner that the most economical method may be readily selected.

Development of Evaluation

Five materials which would reduce the frequency of roof replacements were selected for economic comparison with the present general practice at our Philadelphia refinery of replacing steel tank roofs in kind with $\frac{3}{16}$-inch steel plate. The materials chosen for comparison were bituminous-base and organic resin-base protective coatings on $\frac{3}{16}$-inch steel plate, heavier $\frac{1}{4}$-inch steel plate, galvanized $\frac{3}{16}$-inch steel plate and $\frac{3}{16}$-inch aluminum plate. All five methods of prolonging the serviceable life of refinery tank roofs, particularly in high-sulfur-crude and distillate storage, have been or are being employed by this and/or other companies within the industry. Although the types of materials selected for evaluation in this study do not include all the available materials which economically could be employed, they do cover a broad range of material costs and methods of application. The use of inhibitors, neutralizing chemicals, or oil treating to combat corrosion is not a part of this paper.

In order to establish realistic cost figures for each type of protection and replacement material, the following expenditures were included in the evaluation: 1) tank-cleaning costs; 2) preparation and miscellaneous maintenance; 3) repairs to roof or application of coating; 4) company overheads; 5) downtime; and, 6) rate of return (or interest) on additional investment. The magnitude of each of these expenditures, as affected by the particular protection material and tank diameters, will be developed separately. Simplified equations which summarize the various expenditures will be presented first. Then these equations will be combined to show the over-all economics. The results of the evaluation will be presented in table form for convenience in selecting the most economical type of protection or replacement material.

1) *Tank-Cleaning Costs*

Prior to the actual repairs or replacement of a roof, the tank must be cleaned thoroughly. This involves gas-freeing of the tank and removal of bottom residue. Costs for this work were estimated from the time required for these operations, based on the past experience of the refinery drainage department. For tanks which have been in average oil service, the time required to clean tanks of 20 to 120-feet in diameter has been 1 to 24 days, respectively. However, only about one-half of that estimated time is consumed by manual cleaning—the other one-half being required to gas-free the tank. Therefore, it was assumed that the labor expenditures incurred are those required to maintain a five-man cleaning crew in the field (eight-hour work day) for one-half the estimated cleaning time. Materials and equipment costs for the cleaning work were estimated at $100 per tank. The total cleaning expenditures were then expressed in a simplified equation as $\$140+0.08X$ (where "X" is the horizontal cross-sectional area of the tank in square feet) including assumed company overheads of 38 percent. This equation holds for all replacements or repairs, and is considered to be independent of tank height.

2) *Preparation and Miscellaneous Maintenance*

Before any mechanical work is done which involves the actual repairs to a roof or the application of coatings, certain preparatory steps and miscellaneous maintenance on the tank are generally required. The preparatory steps include rigging, dismantling, scaffolding, lighting, sandblasting, and similar items. Past records of the cost of these operations for metal roof replacements show that they can be expressed in an equation as $\$870+0.29X$. Miscellaneous maintenance to metal roofs, such as nozzles, foam boxes, and gauge boards—which is generally required because of roof

Original presentation as "Economics of Metals and Coatings to Combat Corrosion of Refinery Tank Roofs" was before the 17th annual meeting of the American Petroleum Institute's Division of Refining, San Francisco, May 13, 1952.

TABLE 1

Materials, Fabrication and Installation Costs for Metal Roofs

ROOF CONSTRUCTION	Material Costs (Cents/Lb.)	FABRICATION AND INSTALLATION COSTS (Cents/Lb.) Tank Diameter (Feet)			
		20'	40'	60'	100'
3/16"-1/4" Steel (Welded)	5.0	4.5	3.3	3.0	3.0
3/16" Galv. Steel (Riveted)	7.5	9.5	5.8	4.5	4.0
3/16" Aluminum (Welded)	40.0	11.3	8.3	7.5	7.5

TABLE 2

Protection or Replacement Material	Repair Cost Equation
3/16" Steel (Welded)	$250 + 0.76X
1/4" Steel (Welded)	$250 + 1.00X
3/16" Gal. Steel (Riveted)	$400 + 1.13X
3/16" Aluminum (Welded)	$250 + 1.75X
Organic Resin Coating	$(0.044N)X
Bituminous Coating	$(0.022N)X

repair—was found to be relatively independent of tank size and, therefore, could be assigned an average cost of $300 per tank. Combining the costs of preparation and miscellaneous maintenance, an equation of $1170+0.29X was obtained for metal roof replacements.

When roofs are not replaced with metal, but are protected by application of coatings, the fixed costs are less. The equation for preparation and miscellaneous maintenance, in this case, would be $515+0.27X.

3) *Repairs to Roof or Application of Coating*

The replacement of roof plate with various types of metals involves material, fabrication, and installation costs. The material costs of the metals are well-known and, depending on the quantity of metal required, may easily be determined. The fabrication and installation costs, however, can vary widely because they are influenced by labor rates, field conditions, and size of tank. Estimates of these costs at our Philadelphia refinery are given *in* Table 1.

The roof-repair costs were then calculated from the data in Table 1 and from the roof-material weights at various diameters. When these costs were plotted vs. square feet of cross-sectional area, a correlation was obtained from which the roof-repair equations were derived.

Correction of these equations was made for additional expenditures required to cover the complexities of galvanized and aluminum roof installations. During the fabrication of pregalvanized plate, the metallic coating at or adjacent to the seams is destroyed, thus exposing the base plate. Therefore, it was estimated that 6 cents per square foot is required to apply a protective coating along the roof seams. Similarly, aluminum replacements require that the steel-to-aluminum joints be either electrically insulated or made impervious to moisture so as to prevent local galvanic corrosion of the aluminum roof plates. Such insulation may be accomplished by applying a coating at the joints. Moisture may be sealed out by use of soft aluminum. Costs for this work were estimated at 15 cents per square foot of roof.

A summary of the repair-cost equations is shown in Table 2.

In similar manner the actual cost of organic resin-base protective-coating materials and their application were developed, and these can be expressed in a formula as: $(\$0.044N)X$—where N is the number of coats applied and X is the square feet of coated surface. Data available for bituminous-base coatings indicate costs for this material to be approximately one-half those of organic resin-base finishes, or $(\$0.022N)X$.

4) *Company Overheads*

Company overheads, as employed in this evaluation, are a function of the labor and materials required for repairs and tank preparation. Based on 65 percent overheads for labor and 10 percent for materials, these, when combined, were found to average 37.5 percent for steel and galvanized roofs, 30 percent for aluminum roofs, and 42.5 percent for coatings. Overheads do vary to some extent with tank diameter. However, the use of these averages to reduce the complexity of the computations does not introduce any appreciable error beyond the accuracy of the basic equations.

By applying these company overheads to the basic cost equations for repairs (Table 2) and those established for tank preparation ($1170+0.29X for metals and $515+0.27X for coatings) and then combining the resulting equations with the tank-cleaning cost equation of $140+0.08X, there is obtained a total direct-cost equation for each type of roof protection or replacement material. These are summarized in Table 3.

5) *Downtime*

To prevent a more realistic picture of the expenditures involved in roof protection or replacement, an intangible cost designated as "downtime" was evaluated and added to the direct costs exemplified in Table 3. Inasmuch as downtime involved no real dollar costs, its evaluation was made by assuming that a spare tank must always be available in a refinery to take over the service of any one of the

TABLE 3

Protection or Replacement Material	Total Direct Cost Equation
3/16" Steel (Welded)	$2090 + 1.53X
1/4" Steel (Welded)	$2090 + 1.84X
3/16" Galv. Steel (Riveted)	$2300 + 2.03X
3/16" Alimunum (Welded)	$1985 + 2.73X
Organic Resin Coating	$875 + (0.46 + .06N)X
Bituminous Coating	$875 + (0.46 + .03N)X

TABLE 4

PROTECTION OR REPLACEMENT MATERIAL	DOWN-TIME IN DAYS Tank Diameter (Feet)				
	20'	40'	60'	80'	100'
Welded Metal	15	26	38	53	72
Riveted Metal	17	29	45	62	63
Organic Resin (4 Coats)	17	26	35	46	60
Bituminous (2 Coats)	15	22	29	38	50

hundreds of tanks which may be idle during repair. Thus the investment for this spare tank should be charged against all the tanks which it spares, and should be included in the repair expenditures of these tanks. The portion of the investment of the spare tank which should be included in repair expenditures was determined from the percent of the time which a tank is out of service for repair and the investment of the spare tank. For example, a 3/16-inch steel roof may have a six-year life on a 40-foot-diameter by 40-foot-high tank in sour-oil service. To extend the serviceable life of the roof, a 1/4-inch steel roof has been selected which requires approximately 29 days downtime for installation. The spare tank, therefore, must be in service for this 29-day period, or 1.3 percent of the six-year life of the original 40-foot tank. Because a spare tank of equal capacity would cost approximately $25,000, 1.3 percent of this investment, or $325, is charged as downtime expense. Similar calculations were used to obtain the downtime costs of each type of roof protection or replacement. These calculations were made at a basic tank height of 40 feet.

Downtimes were approximated from the drainage-department cleaning-time estimates and by computations based on the labor required to complete the roof installation. The size of crews who have the skills necessary for each operation was assumed and assigned an hourly dollar value in accordance with the Philadelphia refinery wage scale. From the hourly labor costs per crew and the labor expenditures per operation, the number of eight-hour work days was obtained. The full downtime period was then regarded as the sum of the computed repair time and the cleaning time, with an additional seven days to cover contingencies such as bad weather.

Shown in Table 4 are the estimated downtimes for the various methods of roof protection or replacement. The

figures indicated for riveted construction were employed for all metal roofs other than the $^3/_{16}$-inch welded steel.

Results of Evaluation

A comparison showing a breakdown in dollars of the total costs involved in roof protection or replacement for several of the evaluated materials is given in Table 5. These have been calculated from the cost equations for a tank with a diameter of 40 feet which has a normal service life of six years. There is shown the magnitude of each item involved, and its bearing on the total cost may be clearly visualized. Here it may be seen that the differential costs between alternate replacements and $^3/_{16}$-inch steel plate are relatively lower than might be anticipated. These small differentials may be attributed to the auxiliary expenditures, which show little variation between types of installations and which consume a high percentage of the total costs of the replacements.

The over-all economics of the various types of roof replacements are compared and summarized in Tables 6 and 7. All comparisons are expressed as the approximate number of years (relatively free of maintenance) necessary for the substitute material to break even with the cost of a $^3/_{16}$-inch steel roof. To show the effect on the economics of severity of corrosive service to which the roof is exposed, comparisons are made with a $^3/_{16}$-inch steel roof having 4, 6, and 8 years' normal service life. Because each of the alternate types of roof repair requires for its longer life additional initial investment over the cost of a $^3/_{16}$-inch steel roof, there is also shown the effect on the economics of charging against this additional expenditure such rates of return (or interest) as 0 percent, 10 percent, and 20 percent; i.e., the additional investment of a substitute material, to be justified, may have to compete with other company projects where such rates of return are possible.

GLOSSARY

X = horizontal cross-sectional area of the tank, in square feet.
N = number of coats of protective paint applied.

By applying these tables to a specific tank-roof problem for which the past normal service life of a $^3/_{16}$-inch steel roof is known, it is possible to evaluate the economic advantages of the various methods of roof replacement or protection. Taking the example given previously for a 40-foot-diameter tank and referring to Table 6, a $^1/_4$-inch steel roof would have to last only 7.9 years (with 20 percent interest charged against the additional investment) to break even with a $^3/_{16}$-inch steel roof having a normal life of six years. Inasmuch as the roof thickness has been increased 33$^1/_3$ percent, the serviceable life of $^1/_4$-inch steel may be expected to be at least eight years and, therefore, such a replacement appears to be justified. Also there is shown that galvanized and aluminum roofs require service lives of 9.8 and 12.5 years at 20 percent interest. The life of either galvanized or aluminum roofs in corrosive service has not been clearly established; however, there have been reports from other companies that life greater than 10 years is possible. Life of this magnitude would be sufficient for economic justification under severe corrosive conditions. Similarly, in Table 7, organic resin and bituminous coatings indicate that 3.0 and 2.8 years, respectively, are required to break even when 0 percent interest is assumed. However, the service life of coatings is questionable, and may not be much beyond 2 or 3 years in roof applications. Consequently, at a six-year normal steel life, there would be no dollar advantage for a protective coating.

TABLE 5
Cost Breakdown Comparison for 6 Year Life 40-Foot Diameter Tank

METAL OR COATING	$^3/_{16}$" Steel Welded	$^3/_{16}$" Galv. Riveted	$^3/_{16}$" Alum. Welded	Resin Coating 4 Coats
Tank Cleaning	$ 240	$ 240	$ 240	$ 240
Preparation	1530	1530	1530	855
Repairs: Materials	750	920	1850	50
Repairs: Labor	450	900	600	150
Overheads	1025	1260	1200	450
Downtime	290	325	325	290
Total	$4285	$5175	$5745	$2035

TABLE 6
Over-all Economics
Metals—Life in Years
Required to Break Even With 3/16-Inch Steel

Rate of Return		0%			10%			20%		
Normal Life, Years, $^3/_{16}$" Steel		4	6	8	4	6	8	4	6	8
$^1/_4$" Steel Roof, Tank Dia.	20'	4.1	6.2	8.3	4.3	6.5	8.7	4.4	6.8	9.8
	30-50'	4.4	6.6	8.8	4.6	7.1	9.7	4.9	7.9	12.0
	60-100'	4.6	6.9	9.1	4.9	7.6	10.7	5.4	8.7	13.0
Galv. Roof, Tank Dia.	20'	4.6	6.9	9.2	4.9	7.6	10.5	5.4	8.7	13.5
	30-50'	4.8	7.2	9.6	5.2	8.3	12.2	5.9	9.8	15.5
	60-100'	5.0	7.6	10.1	5.5	9.3	14.3	6.4	10.8	18.5
Alum. Roof, Tank Dia.	20'	4.6	6.9	9.2	4.9	7.6	10.5	5.4	8.7	13.5
	30-50'	5.3	8.0	11.3	5.9	10.1	15.2	7.3	12.5	20.0
	60-100'	6.1	9.3	12.5	7.4	13.5	18.0	10.0	19.2	38.2

TABLE 7
Over-all Economics
Coatings—Life in Years Required to Break Even With 3/16-Inch Steel

Rate of Return		0%			10%			20%		
Normal Life, Years $^3/_{16}$" Steel		4	6	8	4	6	8	4	6	8
Bitum. (2 Coats) Tank Dia.	20'	1.8	2.6	3.5	2.2	3.9	6.8	3.9	8.2	...
	30-50'	2.0	2.8	3.7	2.5	4.4	7.5	4.4	10.4	...
	60-100'	2.1	2.9	3.9	2.6	4.6	8.0	4.7	11.4	...
Organic Resin (4 Coats) Tank Dia.	20'	1.9	2.8	3.7	2.4	4.4	7.5	4.1	10.4	...
	30-50'	2.2	3.0	3.9	2.8	4.8	8.0	5.0	...	...
	60-100'	2.3	3.2	4.2	3.0	5.1	9.2	5.4	...	...

Summary and Conclusions

In general, this study has indicated that: 1) more consideration should be given to increasing the thickness of steel roof installations; 2) in cases of severe corrosive condition, aluminum or galvanized-steel replacements may be warranted; and, 3) extensive use of coatings for roof protection should not be made until the relatively long service life necessary for their justification is established by actual trial installation in the field.

A broad analysis of the comparisons shown in Tables 6 and 7 indicates that $^1/_4$-inch steel roof plates should be used for repair of tank roofs having less, and in some cases more, than 8 years' normal service life. Because of the likely long life of galvanized and aluminum roofs, their use appears warranted where normal service life of $^3/_{16}$-inch steel plate is less than six years. This is particularly evident for tanks with a diameter less than 50 feet. Coating life, for bituminous and organic resin base, longer than two to three years must be obtained to compete, even under the most favorable consideration, with the use of heavier-gauge steel plate or galvanized steel and aluminum.

Although the development of this evaluation and the results which have been presented are specific in application to The Atlantic Refining Company, the approach and methods employed and the interpretation of the results can be applied in a similar manner to any other company's consideration of the same or different methods for tank-roof protection or replacement.

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ACETYLENE—The Newest Petrochemical

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ACETYLENE can now be added to the growing list of chemicals made from petroleum and natural gas. With one plant already in full commercial operation and another under construction, acetylene actually can now be considered one of the petrochemicals.

Acetylene ($CH{\equiv}CH$) was first produced as far back as 1836. Initially, it was used for lighting. It was not until the early part of this century that the welding and cutting of metals by the oxy-acetylene process became important. Later on, it entered the chemical synthesis field, where through such industrial intermediates products as acetic acid, vinyl chloride, etc., it became essential in the production of war gases, dyes, elastomers, plastic materials, and other consumer goods. A full line of chlorinated solvents are derived from acetylene, in addition to acetylene black, a graphite carbon.

The real promise for acetylene as a basic raw material, however, has only developed in the years after the last war. Both in the methods of production and in its chemical utilization has acetylene chemistry opened up new territory for this highly reactive gas.

Current consumption of acetylene (1951) has been estimated at close to 550 million pounds. This compares with an 83 million pound consumption in 1925 and represents over 100 million pound increase over 1950 demand. Roughly about 70 percent of this demand in 1951 was consumed in some phase of chemical production. The remainder went into the metal-working industries as a welding and cutting gas.

Vinyl compounds took the greatest share of the chemical acetylene available, followed by neoprene, chlorinated compounds, the oxygenated chemicals like acetaldehyde, not necessarily in that order. Not yet participating to any significant extent in this consumption of acetylene is the use of the gas for acrylonitrile, synthetic fibers, acrylate resins, and a great variety of chemical intermediates possible through the new high pressure techniques of processing and reacting acetylene. As much as 2 billion pounds of acetylene has been forecast as needed in 1960, but even this figure may be low, since it is based only on what is known right now about acetylene, its possible reaction and potential products. The great potentialities of acetylene are still awaiting the test tube of the chemist and the slide rule of the chemical engineer.

Acetylene Industry Development

The first commercial production of calcium carbide in an electric furnace took place in Spray, N. C., in 1892. Within ten years, scores of furnaces were operating on both sides of the Atlantic. The large-scale utilization of acetylene developed in parallel.

Until recently, all acetylene in the United States was based on this time-proven process; lime and coke are reacted in an electric furnace for the solid calcium carbide. This carbide is then shipped to wherever acetylene is needed. Generation of acetylene is rather simple, involving the addition of water in the following manner:

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

The resultant gas, very pure acetylene, must be handled with care to prevent explosions.

As can be seen above, the manufacture of acetylene by the carbide method is in effect a two-process operation. Since the product of the first reaction, calcium carbide, is in a solid form, it can easily be shipped to any section of the country where a relatively large scale use for the gas is present. On the other hand, the locations for a carbide plant are very limited. The greatest essential is cheap electric power. In addition, a good source of both a proper lime and coke must be near at hand. Niagara Falls, with cheap hydroelectric power and consuming industries, is one of the prime carbide producing areas in this country. In contrast, the Gulf Coast cannot provide the hard lime necessary for operation. In effect, the present industrial picture for acetylene is that there are about ten areas in the United States which can support carbide production, while there are about 200 commercial acetylene generating plants throughout the land. This multitude of acetylene facilities is due primarily to the limited shipping area for the gas. Transportation in cylinders is prohibitive, since the weight of the cylinder and the solvent acetone makes up about 95 percent of the shipping weight. Shipment in cylinders is only for supplying local needs of acetylene for welding and cutting purposes. Any chemical manufacturer will have to depend on an acetylene generator to supply the raw material for his process. In a few instances, where the annual requirements of acetylene by a chemical manufacturer is large, the chemical plant is located close to the carbide furnace and acetylene generator and the gas produced is piped to the chemical acetylene consumer.

There are some obvious advantages to the carbide system. Primarily, as stated above, the acetylene produced is very pure and needs no separation from other gases and purification. In addition, small generating units are economically feasible. One other factor is very important. The initial investment cost for a carbide plant and the required acetylene generating facilities are less expensive than a comparable plant making acetylene from natural gas.

Turning to the new natural gas processes, there are some strong disadvantages. Primarily, the gas produced by this method is very low in acetylene content, averaging less than ten mol percent. The manufacturer, therefore, must involve himself in separating the acetylene from the other constituents and thereafter purifying the gas. This problem usually offsets any savings in cost for the actual production of acetylene from natural gas as against the regular carbide method. In addition, to be economically sound, a natural gas acetylene plant must have a large capacity. This effectively eliminates such an undertaking from all acetylene applications, except in those cases where the gas is used in an integrated or adjacent plant in chemical synthesis. Although at first sight this may

seem a serious disadvantage, in all probability, this necessary large capacity may help to further acetylene from natural gas, since the expected increase in the demand for the gas will stem mainly from consumption as a chemical raw material. Other individual disadvantages of the various processes are discussed later.

In the face of such an unbalanced pro and con picture, the big question arises: Why use any of the natural gas processes, if they have the above disadvantages, while the carbide process, a proven method, has such strong points in its favor? The answer is rather simple. The carbide method needs large quantities of cheap electric power in the manufacture of the calcium carbide itself. Such good power areas as Niagara Falls are not only limited, but their power facilities are being taxed to the limit. Consequently, any chemicals producer who requires acetylene for his processes, has been forced to investigate the natural gas methods.

Up to this time, two companies have decided to enter this new petrochemical field. Carbide & Carbon Chemical Company is operating the only acetylene plant using methane in the U. S. According to the company, their plant at Texas City, Texas, has met with such impressive results that they are trying to enlarge its capacity. The initial capacity of the plant is far larger than any unit built in Germany during the war. Integrated with this acetylene unit is the equipment for making vinyl compounds, important plastic raw materials.

Monsanto Chemical Corporation has also decided to enter the acetylene picture in the Southwest. The process also will use natural gas and oxygen to produce acetylene. According to company announcements, the total plant (also at Texas City) will cost $30 million, such cost to include the investment of both the oxygen plant and the acrylonitrile plant, which will consume the acetylene produced. A major portion of this acrylonitrile, and therefore the acetylene, will end up as synthetic fibers.

These are the first two companies. Others will undoubtedly follow. A few companies are undecided. Others have temporarily decided against the natural gas process. For example, Air Reduction has scheduled a new 150,000-ton carbide plant in Kentucky to begin operations in 1953. Even Carbide and Carbon, despite the success of the Texas City unit, also has effected expansion of carbide facilities at Niagara Falls, Sault Ste. Marie, Ashtabula, and on the West Coast. All these enlargements, however, are severely handicapped by the output of cheap power. It is in this important respect that natural gas can become an important source of acetylene. Research and development is continuing. A number of companies are participating, each with an eye to this petrochemical future.

Hydrocarbon Processes

Regarding the technology of the processes for manufacturing acetylene from natural gas, there are two basic steps involved in the production. The primary production of acetylene is a pyrolysis step. Since the resulting gases are low in acetylene content (roughly ten percent), the second problem is to separate and purify this acetylene to a commercially acceptable state. It seems that most attention has been paid until recently to the pyrolysis step. The cold money facts, however, show that the major investment and operating costs appear in the separation and purification. Anyone considering entry into natural gas based acetylene production must solve the economics of this problem.

So far, the primary cracking step in all processes offered for commercial use are essentially non-catalytic cracking operations. The difference is in the methods of producing and applying the heat. For acceptable acetylene concentrations in the effluent gases, the temperature is normally in excess of 2600° F.

General techniques for this pyrolysis step determined after years of experimentation resulted in agreement that the reaction time be short, provided for the rapid quenching of the effluent gases, and operation at reduced pressures.

The separation and purification of the cracked gases has been carried out by two different methods: hypersorption, solvent extraction, and both in combination. The actual process used is determined by the composition of the effluent gases and the cost. So far, in American operations, the solvent extraction process seems to be favored.

Right now, four basic processes for cracking natural gas to acetylene are offered for commercial use in this country: 1) the Schoch electric arc process, 2) partial oxidation with oxygen, 3) partial oxidation with air, and 4) the Wulff regenerative furnace process. The Carbide and Carbon process uses partial oxidation with oxygen. Monsanto's plant now under construction will use the same general process with solvent extraction of the acetylene gas.

Briefly, the four processes can be described as follows:

1) In the *Schoch process*, the gas passes through six reaction chambers in series with each chamber working three arcs in parallel. The feed gas is introduced by three impellers, each acting as an electrode and with opposite electrodes mounted outside each opening. A constant current is one of the requirements of the process. The chamber temperature is limited to 550° F. by recirculating the gas. Carbon black forms and is removed. This carbon black may furnish one economic inducement for this method, but the relatively complicated electric arc process involved and the high power consumption (as much as in calcium carbide production) have not made the process commercially acceptable at this time.

2) The *partial oxidation of natural gas with oxygen* has had the best reception. In this process, shown in Figure 1, preheated natural gas and oxygen enter a burner. Therein the gases are thoroughly mixed, reacted, and quenched. Additional quenching is provided in the spray tower, while the gas is cleaned in a Cottrell precipitator. Economic advantages for the process are the low energy costs and the by-product gas suitable for Fischer-Tropsch synthesis. Although the oxygen plant represents a substantial additional investment, such cost can be reduced by integrating this plant with an ethylene oxide production unit.

3) The *partial combustion of natural gas with air* is very similar to the oxygen process. The preheat temperature is higher, but the oxygen plant investment not necessary. Besides, the effluent gas is more dilute in respect to acetylene content and the Fischer-Tropsch raw material not produced because of the introduction of nitrogen into the reaction stream.

4) In California, a pilot plant demonstration unit utilizing the *Wulff process* has been operated for some time. In the reaction method, the gas is fed alternately into each of two reaction chambers. The gas is introduced at the bottom, passed upwards through heated bricks. While passing down the other side of the cracking chamber the gas heats the bricks located on that side. Quenching and spray tower complete the reaction. During the heating cycle, gases are burned to heat the bricks on the cracking side of the chamber and discharged to a stack. The two furnaces alternate in the cracking and heating cycle, each phase lasting about one minute. A temperature of 2600° F. is reached in the cracking phase. A minimum power cost makes this process very attractive, but the complicated construction of the brick filled chambers and the high

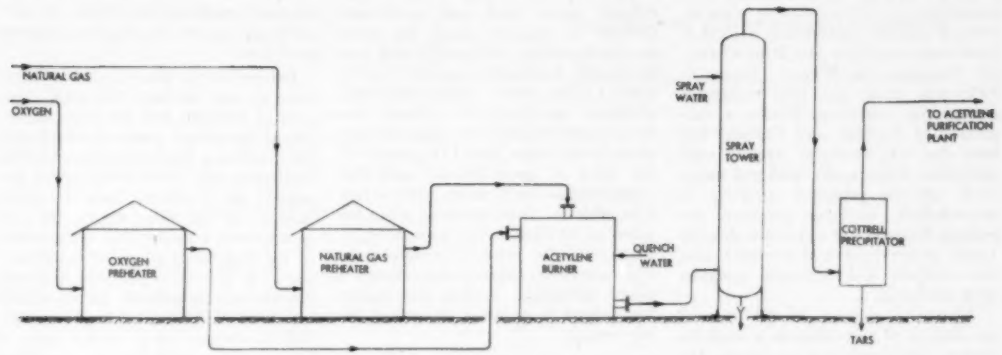


Figure 1. Partial Combustion Process for the Manufacture of Acetylene.

maintenance costs are handicaps. The production of significant quantities of ethylene complicates the separation and purification of the gases produced.

Either hypersorption or solvent extraction can be used for any of the cracking processes described, the actual application depending upon such factors as the concentration of the acetylene in the cracked gas, and the presence of such products as oxygenated compounds, ethylene, etc. As previously stated, these purifying steps are receiving the most attention now, since it has been realized that their operation contributed that part of the cost factor which can determine the competitive quality of the process in relation to the calcium carbide process.

Acetylene Chemicals

The chemical derivatives of acetylene so far can be classed generally in six different categories: vinyl compounds, oxygenated products, chlorinated products, neoprene elastomer, acrylonitrile, and the high pressure synthesis compounds from the Reppe reactions. The first four groups are at the present time important in the United States. They use the bulk of the acetylene consumed in chemicals manufacture. Acrylonitrile is still not made from acetylene, but the first plant is under construction. Its future in this field is very promising, especially with the rapid development of the synthetic fiber industry. The products of high-pressure synthesis are still in their commercial infancy. This operating method, however, promises to make acetylene one of the best chemical building blocks available to American industry.

Vinyl Products

The vinyl resin market is one of the best outlets for acetylene at the present time. About one quarter of all acetylene used in chemical manufacture finds its way into such products as vinyl chloride, vinyl acetate, and polyvinyl alcohol. This is in addition to the output of these products from the cracking of ethylene dichloride. The ratio between vinyls produced from acetylene and from ethylene is nearly equal, with present plant capacities in the ratio of 55 to 45 for acetylene and ethylene respectively. The two processes involved are the reaction of acetylene with hydrogen chloride and the production from ethylene and chlorine. From an economic standpoint, neither process seems to have any significant cost advantage.

Present production of all vinyl materials is over 300 million pounds. This must be compared with a pre-war output of only a little over one million pounds per year. Undoubtedly, the war contributed to the rapid expansion in the demand for these materials, but lately, a healthy growth has been developed in many consumer markets for polyvinyl chloride.

Since Korea, the supply of vinyl materials has been rather tight, due primarily to the shortage of chlorine and the increased demand for these plastics because of the withdrawal of other plastics, such as styrene and polyethylene, from the consumer market. Since the vinyl plastics and monomers have only limited military uses, they have been used to replace scarcer materials in civilian consumption. This defense increase in vinyl consumption, however, is not the only growth trend for these materials. A fast growing application for polyvinyl chloride, for example, has been in the thin film products, especially in such mass production items as drapes, curtains, shower curtains, raincoats, etc. In addition, a new large-scale market is rapidly opening up for polyvinyl chloride as plastic floor coverings. The vinyl plastic seems to have excellent wear properties when compared with linoleum. In another respect, vinyl chloride is also entering the synthetic fiber market. Dynel, discussed later under acrylonitrile, uses up to 60 percent vinyl chloride.

Manufacturers of the vinyl monomers are sensing the future potential for these products. Present expansion plans are based mainly on the production of these plastics from acetylene gas. The Carbide & Carbon natural-gas-based acetylene in Texas is used primarily in the company's manufacture of vinyl chloride and acetate monomers. All other acetylene vinyls are made from the calcium carbide generated gas. The actual predominance of one process over the other in the future again will be determined by the cost of raw materials. From the present standpoint, acetylene seems to be favored for any new facilities planned.

Oxygenated Products

Acetaldehyde, acetic acid, and acetic anhydride are closely tied together both technically and economically, since the largest consumption of acetaldehyde is in the manufacture of acetic acid and anhydride, and since one of the principal raw materials for the anhydride is synthetic and recovered acetic acid.

Originally, the principal raw material for acetaldehyde was ethanol. About 30 to 40 percent of total ethanol output still is consumed in the preparation of aldehydes, the most important one being acetaldehyde. However, the use of other raw materials has been

gaining steadily, especially since the establishment of the Celanese plant in 1945. A similar hydrocarbon oxidation plant constructed by McCarthy Chemical Company, in Winnie, Texas, in 1949 was never put into successful commercial operation. Niacet, a subsidiary of Carbide and Carbon, has been the only producer starting with acetylene. Since acetic acid and anhydride are the principal products of acetaldehyde, alternate processes for making the acid and anhydride directly (such as the Hydrocol process) also can compete with alternate acetaldehyde processes.

About 75 percent of the current production of acetaldehyde is used for making acetic acid and anhydride. The remainder is used in the production of butanol (20 percent) and miscellaneous products (5 percent).

The alternate methods for the production of acetaldehyde, both commercial and potential, are

1) Production by the catalytic hydrolysis of acetylene. The yield is 95 percent, and the consumption of acetylene is 0.62 pounds per pound of acetaldehyde produced.
2) By-product in the manufacture of acetic anhydride from ethylidene diacetate (prepared from acetylene). It is also a by-product in the manufacture of butadiene from alcohol.
3) The vapor phase oxidation of alcohol.
4) The oxidation of natural gas hydrocarbons, such as propane and butane, and
5) The Fischer-Tropsch process.

About 70 to 75 percent of the total acetic anhydride production is used in the production of cellulose acetate rayon. Another 15 to 20 percent goes into resins and plastics such as cellulose acetate and vinyl acetate, while the remaining 5 to 12 percent is used for various miscellaneous chemicals. Until 1950, duPont produced the anhydride from acetylene, but discontinued operations that year.

About 60 percent of all new synthetic acetic acid is converted to anhydride, 30 percent is used as the raw material for various organic ester solvents such as ethyl acetate, and the remaining 10 percent is used for miscellaneous purposes. The complexity of the industry can best be demonstrated by naming the many processes which are available for the actual and probable manufacture of acetic acid:

1) From acetaldehyde. (About 1.1 pounds of acetaldehyde is required per pound of 100 percent acetic acid.)
2) The vapor phase oxidation of alcohol.
3) The fermentation of alcohol.
4) As a by-product of wood distillation.
5) From methanol and carbon monoxide.
6) By-product of hydrocarbon oxidation.
7) Fischer-Tropsch synthesis.
8) By-product in furfural manufacture.
9) By-product in the manufacture of the acetic acid and acetic anhydride products such as cellulose acetate.

The production outlook for acetaldehyde, acetic acid, and acetic anhydride is complicated by their inter-relationship, technically and economically. A detailed economic survey made by the authors shows that acetaldehyde can be made without loss from acetylene when the price of acetylene is not more than 111 percent of the price of acetaldehyde; and that acetaldehyde can be made without loss (via ethanol) from ethylene, when the price of ethylene is not more than 71 percent of the price of acetaldehyde. The acetylene process also enjoys a slight advantage in that it requires less capital as an initial investment for equipment.

Chlorinated Hydrocarbons

The chlorinated hydrocarbons use less than 10 percent of all acetylene consumed for chemicals. Trichloroethylene, on a volume basis, is the most important chlorinated solvent in use today. It has displaced carbon tetrachloride for many applications. It is simply made by chlorinating acetylene to form acetylene tetrachloride, which is then treated with a lime suspension to dehydrohalogenate one mole of HCl.

Further syntheses are possible by chlorinating the trichloroethylene to pentachloroethane, and dehydrohalogenation to perchloroethylene. All of these compounds may be used as solvents. Further chlorination of perchloroethylene will give hexachloroethane, which was widely used during the last war as an ingredient of smoke bombs.

Trichloroethylene can also be derived from ethylene; perchloroethylene from propane, carbon tetrachloride, or ethylene; and hexachloroethane from carbon tetrachloride or ethylene.

The most important use of tetrachloroethane is as an intermediate in the preparation of trichloroethylene, and other chlorinated hydrocarbons in the series. It is also a specialized solvent and weed killer. The principal commercial preparation is by the chlorination of acetylene.

Trichloroethylene has been manufactured in the U. S. since 1925. It is of great value as a solvent because it is non-flammable and shows greater stability over a wide range of conditions than most other chlorinated hydrocarbons. It may be used in the presence of air, water, and light with any common construction metals at temperatures up to 248° F. It is used for metal-degreasing, dry-cleaning, and extraction, and as a freezing point depressant with carbon tetrachloride as an extinguisher. More than 50 percent of its production is used for degreasing and metal cleaning. In the production from acetylene, the yield is 90 percent, requiring 2.2 pounds of acetylene per pound of perchloroethylene produced.

Before World War II, carbon tetrachloride was the most important competitive product, and the most important of the solvent group of chlorinated hydrocarbons. Since that time, trichloroethylene has become the more important on a volume basis. Its great increase in use came during the war as a carbon tetrachloride replacement in the degreasing of metal machinery parts. It has also partially replaced carbon tetrachloride in the dry-cleaning field. Although carbon tetrachloride is cheaper on a weight basis, it has a higher vapor pressure, resulting in greater operational loss, and actual higher unit cost. In certain dry-cleaning operations, the more expensive perchloroethylene is preferred since it does not attack cellulose acetate dyes.

The most important use of pentachloroethane has been as an intermediate in the manufacture of perchloroethylene. It is also used in small amounts in soil sterilization and as a sink-and-float liquid in coal beneficiation, despite its relative susceptibility to hydrolysis. It has little use as a solvent.

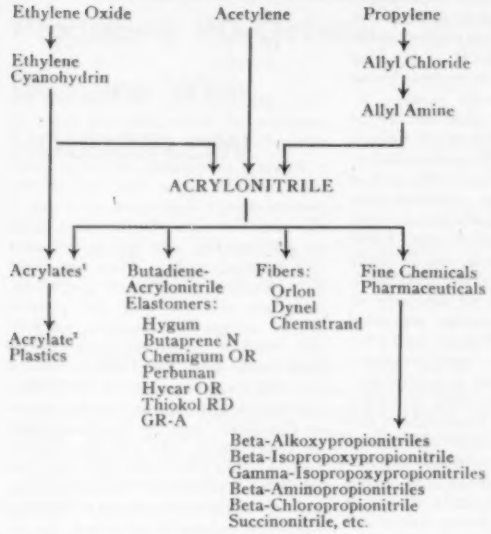
Perchloroethylene can be used as a cleaning and degreasing agent in the presence or absence of air, water, and light with any of the common construction metals at temperatures up to 248° F. It is commonly used as a dry-cleaning solvent, a degreasing agent, a worm remedy, and as an intermediate, as in the preperation of hexachloroethane. It is non-flammable.

Neoprene

Neoprene is a special-purpose rubber developed by duPont on the basis of original research on acetylene polymers at the University of Notre Dame by Julius Nieuwland. It is produced from monovinylacetylene and hydrogen chloride. Monovinylacetylene, in turn, is made by the catalytic polymerization of acetylene. The chief characteristics of neoprene are low combustibility and high resistance to heat, oxidation, ozone, sunlight, and oils. The elastomer is made only by E. I. duPont de Nemours & Company, Inc., at two plants at Louisville, Ky., and Deep Water, N. J. Both plants have a designed capacity of more than 150 million pounds.

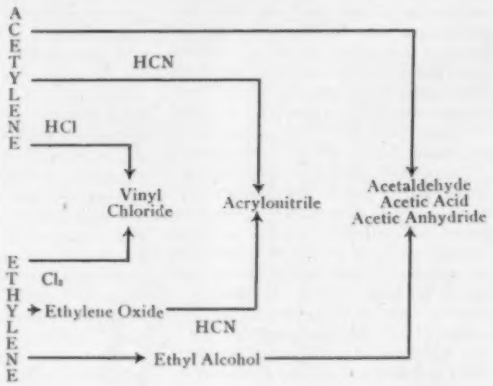
Neoprene has reached a state of development where it will continue to be produced and consumed in the U. S. in volume sufficient to insure its rapid expansion to meet potential full-scale wartime needs. Current production is

FIGURE 2
Production and Derivatives of Acrylonitrile



[1] Polyacrylic acid and derivatives.
[2] Does not include the methacrylates (Lucite, Plexiglas), which are derived from acetone cyanohydrin.

FIGURE 3
The Competition Between Acetylene and Ethylene



about 110-125 million pounds per year.

Acrylonitrile

The acrylonitrile market appears to be the most promising outlet for natural gas acetylene. There are three different processes which produce acrylonitrile: 1) the addition of hydrogen cyanide to acetylene, 2) from ethylene by the dehydration of ethylene cyanohydrin, and 3) from propylene. The ethylene process is dominant right now, but natural gas acetylene may well absorb most of the future demand for this intermediate. The propylene process has not been developed to commercial acceptance.

The production of acrylonitrile has been rather limited until recently with its growth dependent primarily upon application of the chemical for special purpose synthetic rubbers and a limited amount of plastics. Up to this time, the only producer of acrylonitrile, American Cyanamid, uses the ethylene oxide method. In the forefront of the acetylene development, however, is Monsanto with a $30 million building project for natural gas acetylene and the derivative acrylonitrile. American Cyanamid for the time being will probably stay with calcium carbide. During the last war, total U. S. production of acrylonitrile was 20 million pounds per year. Current production capacity is between 25 and 30 million pounds. Figure 2 shows the inter-relation of acrylonitrile, its raw materials and its derivatives.

About 10 million pounds of acrylonitrile were consumed annually at the peak of war production for such polybutadiene-acrylonitrile synthetic rubbers as GR-A, Thiokol RD, Hygum and Hycar OR. Up to now, wide acceptance of these rubbers has not materialized, due primarily to their relative high cost. Under the most favorable circumstances, these synthetic rubbers are not suitable for the large markets in tires and similar products, but find best outlets in such special property rubbers as oil resistant elastomers.

Small amounts of acrylonitrile are used as intermediates for the production of such fine chemicals and pharmaceuticals as succinonitrile, etc. These products are listed in the chart on competitive acrylonitrile processes. The use of acrylonitrile for acrylic resins is not promising, since this type of plastic material can be more readily produced more directly from acetylene (see below), ethylene oxide, and even lactic acid. The extreme reactivity of acrylonitrile will eventually be used for the manufacture of a wide variety of chemical intermediates. Pilot plant development on a number of products is under way. A recent example, which may become a very important consumer of acrylonitrile, is the synthetic poly-electrolyte soil conditioner Krilium. Monsanto, the producer, claims that Krilium is 100 to 1000 times as effective in improving soil structure as ordinary compost, manures, or peat moss. The material is made by polymerizing acrylonitrile and then hydrolizing it. The potential for Krilium seems great, depending probably upon a reduction in the price of the soil conditioner and its actual performance in large-scale use.

The rapid development of synthetic fibers in competition with natural fibers and rayon, is the most promising application for acrylonitrile right now. Polymerized acrylonitrile is the foundation of a number of low-cost continuous filament synthetic fibers with good resistance to heat, light, and chemicals. Such products may displace some of the markets for nylon. In the staple form, these fibers can compete with wool. More important than either of these substitutions, may be the use of the new synthetics in blends with established materials.

Orlon, the first of the acrylonitrile fibers, has been in production since 1944 by duPont. In 1950, the company began large-scale commercial production at Camden, N. J., in a plant with an initial capacity of 6.5 million pounds. By 1953, the expected capacity for Orlon is 40 million pounds. The fiber is essentially 100 percent acrylonitrile. Carbide and Carbon makes Dynel, a fiber using about 40 percent acrylonitrile. The first commercial unit began operation in 1950, a second in 1951. In February, 1952, the company announced its intention to build a new plant at Spray, S. C., with a capacity of 20 million pounds. Capacity in 1953 is estimated at 30 million pounds. Chemstrand's Acrilan contains about

85 percent acrylonitrile. This is relatively small when compared with the more than one billion pounds of rayon manufactured last year. Actually, the production rate for the acrylonitrile fibers is important when it is realized that commercial production for these fibers goes back only to 1950. Total requirement for acrylonitrile in 1962 for these three fibers alone has been estimated at over 270 million pounds.

Large-scale acetylene production from natural gas is ideally suited for this growing fiber market. Requirements of acetylene are on a large enough scale to permit the operation of acetylene plants using natural gas as an integral part of the fiber production unit. At the moment, ethylene oxide is still the dominant raw material for acrylonitrile, but the synthetic fiber industry will demand more acrylonitrile than can be supplied through ethylene oxide. Acetylene will undoubtedly fill this gap in the supply.

High Pressure Syntheses

After the last war, recent developments of the German chemical industry were made public. The most impressive features in the advance of chemical technology was the discovery that acetylene had been used at elevated temperatures and pressures to manufacture a number of scarce products.

The extreme reactivity of acetylene, due to its triple bond structure, long has been known to chemists. It was always considered as a potentially great building block for organic chemicals. One drawback, a monumental one, however, existed in that acetylene becomes highly explosive at elevated reaction conditions. To reduce this hazard, three principles of operation were investigated by the Germans: 1) they tried to eliminate the factors which initiate decomposition, 2) they adopted methods which reduce the violence of decomposition, and 3) they constructed the plants to withstand the reduced force of decomposition. In general, the following operating techniques prevailed in most of their processes: water-ringed compression pumps were used, explosion proof exhaust valves were installed, the acetylene was diluted, usually with inert nitrogen, and most effectively, free spaces in the reaction equipment was limited to a maximum of 0.25 square inches diameter by stuffing all pipes and other spaces with small tubing. At the same time, a thorough search into catalyst behavior was conducted.

Four general processes were developed using acetylene at high pressures and temperatures: 1) *vinylation*, where a vinyl radical ($CH_2=CH—$) is added to a compound, the acetylene losing one of its bonds in the process, 2) *ethynylation*, which adds the triple bond acetylene to a chemical without disturbing the bond, 3) *carboxylation*, the reaction of acetylene with carbon monoxide, and 4) the *polymerization* of acetylene into cycloolefins of eight, ten, and twelve member rings. Literally, scores of chemicals can be made by these reactions. During 1941-1942, about two percent of all acetylene or close to 3 million pounds, consumed in Germany went into these high pressure reactions. Their most important products were Periston, polyvinyl pyrrolidone, a blood plasma extender, Korosin, an adhesive Buna rubber and fabric, and many other derivatives. The polyvinyl pyrrolidone is now being produced in the U. S., along with a few other chemicals. Principal development work is being carried out by General Film and Dye Corporation in Graselli, N. J. The cost of most acetylene products, like butadiene, is still too high to compete with established commercial processes from other raw materials. The future for these syntheses, however, looks very good. Most basic experimentation must still be carried out and suitable, low cost processes developed, but these high pressure operations with acetylene promise at least as wide a range of products from this gas as are now being made from olefinic gases like ethylene.

Competition With Ethylene

The observant reader will by this time have noticed a very curious fact. In the discussion on acetylene chemicals above, the competition of acetylene and ethylene as starting materials for the same end products has been referred to repeatedly. The cumulative effect of these references is that ethylene must be a direct, and a serious, competitor for acetylene in a number of chemical syntheses. The truth of this statement is borne out by the chart, Figure 3, showing the relationship of these two chemical building blocks to vinyl compounds, acrylonitrile and the oxygenated products. The structures of acetylene and ethylene are very similar. Both have two carbon atoms. Ethylene has a reactive double bond, while acetylene has an even more active triple bond:

$HC \equiv CH$ — *Acetylene*

$\begin{matrix} H & H \\ | & | \\ HC = CH \end{matrix}$ — *Ethylene*

This makes obvious the fact that the reactions of both chemicals must be somewhat similar.

In vinyl compounds, acetylene processes produce more than half of the present output. Expansion plans are in the same direction. On the other hand, in acrylonitrile, ethylene is the only raw material so far. When the Texas City Monsanto plant begins operations, acetylene will also enter this picture. In the oxygenated products, no definite trend for either raw materials has been established. Ethyl alcohol is still favored more than acetylene. Neither chemical can be of extreme importance in this field, once the Hydrocol plant in Texas comes into full capacity operation. This plant alone can take care of about 5 percent of the present output of acetic acid. Several technical problems remain to be solved. In any case, the future potential of acetylene should not be tied with these oxygenated products. Instead, the rapidly expanding vinyl and synthetic fibers markets should be the main battleground for the two raw materials. In both cases, acetylene seems to be holding a slight edge from today's vantage point. Further development work may really place acrylonitrile into the acetylene column. In any event, neither ethylene nor acetylene faces a precarious future. Both are finding ever widening applications in fields where they are not directly competitive.

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Producing 90-Octane Gasoline With HOUDRIFLOW

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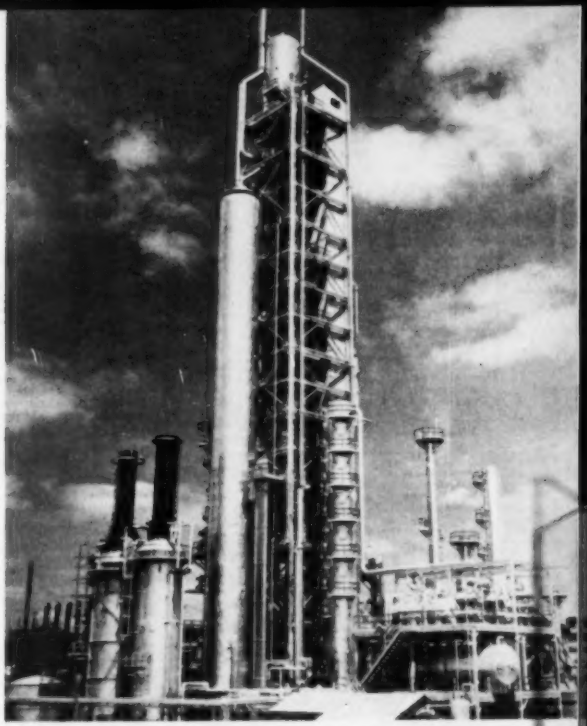
Drumright, Okla.

THE FIRST complete performance data on a Houdriflow unit to be published are tabulated in this article on the catalytic cracking unit at Drumright, Okla., operated by Tide Water Associated Oil Company. In addition to a discussion of the process flow, operating hints are outlined from the first year's experience with this unit.



Houdriflow Unit Showing the Heaters, Reactors, Kiln and Catalyst Storage Hopper.

TIDE WATER'S Houdriflow unit at the Drumright refinery, the second catalytic cracking unit of its kind installed in the industry, has been in operation since 1950. The first complete performance data to be published are included in the accompanying tables to show the operation of the unit at the present time. Table 1 gives typical liquid yields from the unit, while Table 2 outlines the typical operating date. An inspection of the products is provided in Table 3.

Throughout most of its operating history, the unit has operated fairly close to its design charge rates of 4500 barrels per day fresh feed and 2250 barrels per day of recycle. Cracking a virgin gas oil from the distillation units in the refinery, the process produces 90-octane (CFRR) gasoline as its major product. The catalyst employed in this moving-bed type process is a synthetic, bead type. A brief review of the process flow points to the

TABLE 1
Typical Liquid Yields

PRODUCT	Volume Percent of Fresh Charge
C_3-C_4 Cut	19.69
Stabilized Gasoline	51.91
Tractor Fuel and/or No. 2 Fuel Oil	21.03
No. 5 Fuel Oil	11.73
Total Liquid	104.36

Figure 1. Flow Diagram of Houdriflow Catalytic Cracking Unit.

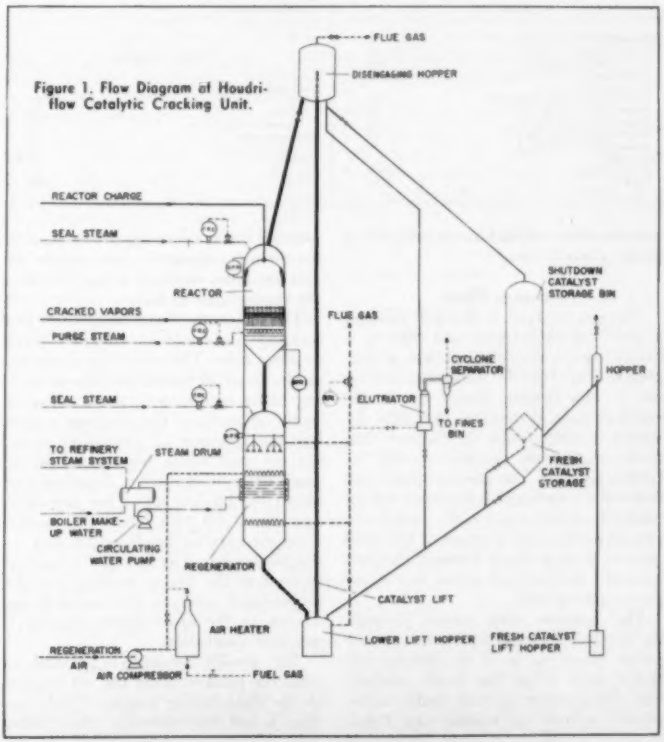


TABLE 2
Operating Data

REACTOR	
Temperatures, °F.	
Feed Nozzle	740
Reaction Zone	845
	850
	845
	875
Above Disengager	935
Above Purge Plate	890
Catalyst Outlet	850
Vapor Outlet	870
Pressures	
Feed Nozzle, psig.	11.6
Top Nozzle, psig.	7.0
Vapor Outlet, psig.	5.8
Top Seal, psi.	0.2
Kiln-Reactor Differential, psi.	1.4
Flows, Lb./Hour	
Sealing Steam	900
Purge Steam	3080

KILN	
Temperatures, °F.	
Middle-Top Burning Zone	890
Above Air Inlet	1250
Below Air Inlet	1160
Below Cooling Coils	1140
Above Flue Gas Outlet	1090
Catalyst Outlet	1085
Cone Section Disengager	1075
Air to Kiln	900
Flue Gas from Bottom Zone	1065
Flue Gas to Atmosphere	1085
Flue Gas from Disengaging Hopper	925
Pressures	
Top Seal, psig.	0.2
Kiln Seal, psig.	7.2
Blower Discharge, in. Hg	19.2
Total Flue Gas Outlet Header, scfm.	7.1
Catalyst Lift Hopper, psig.	4.1
Flows	
Sealing Steam, lb./hour	720
Water to Coils, gpm.	140
Flue Gas to Lift, cfm.	4500
Bed Flue Gas, scfm.	200
Catalyst Circulation, tons/hour	240

HEATER	
Temperatures, °F.	
Fresh Charge	95
Total Charge to Heater	460
Heater Outlet	740
Pressure, psig.	
Fresh Charge Pump Discharge	220
Heater Inlet, Pass No. 1	52
Heater Inlet, Pass No. 2	55
Heater Outlet, Pass No. 1	25
Heater Outlet, Pass No. 2	28
Flows, Bpd.	
Fresh Charge	4500
Recycle	2486

MAIN TOWER	
Temperatures, °F.	
Tower Bottoms	665
Above 8th Tray	500
Top	275
Bottom to Storage	190
Quench Pump Discharge	660
Quench from Charge Exchanger	510
Quench to Tower	480
Circulating Reflux from Exchanger	340
Draw-Off to Burning Oil Stripper	450
Draw-Off to Tractor Distillate Stripper	360
Gasoline from Overhead Receiver	94
Pressure, psig.	
Tower Bottom	4.8
Flows	
Deethaniser Charge, gph.	3600
Tractor, Distillate to Storage, gph.	600
Burning Oil to Storage, gph.	1780
Steam to Tractor Dist. Stripper, lb./hour	120
Steam to Burning Oil Stripper, lb./hour	100

DEETHANIZER	
Temperature, °F.	
Absorption Oil to Tower	75
Tower Top	105
Above Tray No. 19	100
Tower Bottom	250
Pressures, psig.	
Overhead	225
Bottom	225
Flow, gph.	
Absorption Oil from Depent.	1100

DEBUTANIZER	
Temperatures, °F.	
Top	155
Bottom	365
Overhead Receiver	110
Debut. Gaso. After Cooler	85
Pressures, psig.	
Overhead Receiver	165
Bottom	168
Flow, gph.	
Overhead Reflux	4080

DEPENTANIZER	
Temperatures, °F.	
Top	190
Bottom	275
Overhead to Condenser	70
Pressures, psig.	
Overhead Receiver	16.2
Bottom	17.0
Flow, gph	
Charge	1800

TABLE 3
Inspection of Products

GASOIL CHARGE	
Gravity, °API	28.6
Distillation, Percent Over	
IBP, °F.	165
@ 300 °F.	1.0
@ 400 °F.	2.3
@ 450 °F.	4.4
@ 600 °F.	16
@ 650 °F.	34
@ 700 °F.	53
Sulfur, Percent	0.37
Conradson Carbon, Percent	0.30
Pour Point, °F.	85
Aniline Number	185
Viscosity, SUS @ 100 °F.	115

STABILIZED GASOLINE	
Gravity, °API	58
Color	+26
RVP	8.8
Distillation, °F.	
IBP	97
10 Percent	126
20 Percent	140
50 Percent	214
90 Percent	380
E.P.	432
Rec. Percent	98
Octane Number	
Clear	90
@ 1cc TEL	94.5
@ 2cc TEL	96.5
@ 3cc TEL	97.0

C_3-C_4 CUT	
Composition, mol Percent	
Ethane	2.19
Propane	6.16
Propene	8.19
Isobutane	35.06
Isobutene	8.91
Butene	26.81
n-Butane	12.68

TRACTOR FUEL	
Gravity, °API	26.0
Distillation, °F.	
IBP	428
10 Percent	448
20 Percent	454
95 Percent	480
E.P.	492
Flash, Open Cup, °F.	210
Flash, Closed Cup, °F.	190

NO. 2 FUEL OIL	
Gravity, °API	28.5
Distillation, °F.	
IBP	484
10 Percent	518
20 Percent	526
90 Percent	580
E.P.	606
Flash, Open Cup, °F.	240
Flash, Closed Cup, °F.	210

RECYCLE	
Gravity, °API	26.0
Distillation, °F.	
IBP	520
10 Percent	578
20 Percent	590
90 Percent	688
E.P.	710

CATALYST	
Average Size, Inches	0.152
Carbon (Kiln Outlet), Percent	0.119
Carbon (Reactor Outlet), Percent	0.817

modifications which have developed up to the present time.

Process Flow

The gas oil feed is charged through a series of exchangers and then to a heater where the feed reaches a temperature of 740° F. Referring to Figure 1, the heated charge enters the reaction zone through a specially designed nozzle which is located centrally within an annular curtain of falling catalyst. The unevaporized portions of the feed are intercepted by the catalyst curtain and by this means are vaporized. A small portion of the total catalyst stream flows through the peripheral catalyst feed pipes to the reactor catalyst bed.

The mixture then passes through the catalyst disengaging section, where purge steam is used to remove the heavy ends from the bead catalyst. The disengaging section, built somewhat similarly to bubble cap trays, permits the cracked vapors to pass to the main fractionating tower while the catalyst flows through a seal leg into the regenerator or kiln.

The regenerator consists of two burning zones and an intermediate cooling zone. The cooling zone includes five coil banks, the rate of cooling being regulated by the number of banks in service. The cooling section has the function of providing steam for the unit while removing heat of combustion of the coke. Entering just above the cooling zone, the regeneration air at 10 psig burns the carbon from the catalyst beads, which flow to the lift hopper. The flue gas so formed is used as the lifting medium for the regenerated catalyst, the excess being vented to the atmosphere through a pressure controller.

The gas-lift principle is used to raise the catalyst from the lift hopper to the disengaging hopper. Fresh catalyst is fed intermittently (three times a day) into the lift hopper from a bin by means of flue gas pressure. The catalyst loss amounts to 2.25 to 2.50 tons per day. A portion of this loss is represented by the fines removed in the elutriator, to which a portion of the lower zone flue gas is diverted for continuous classification of the system catalyst through the removal of fines.

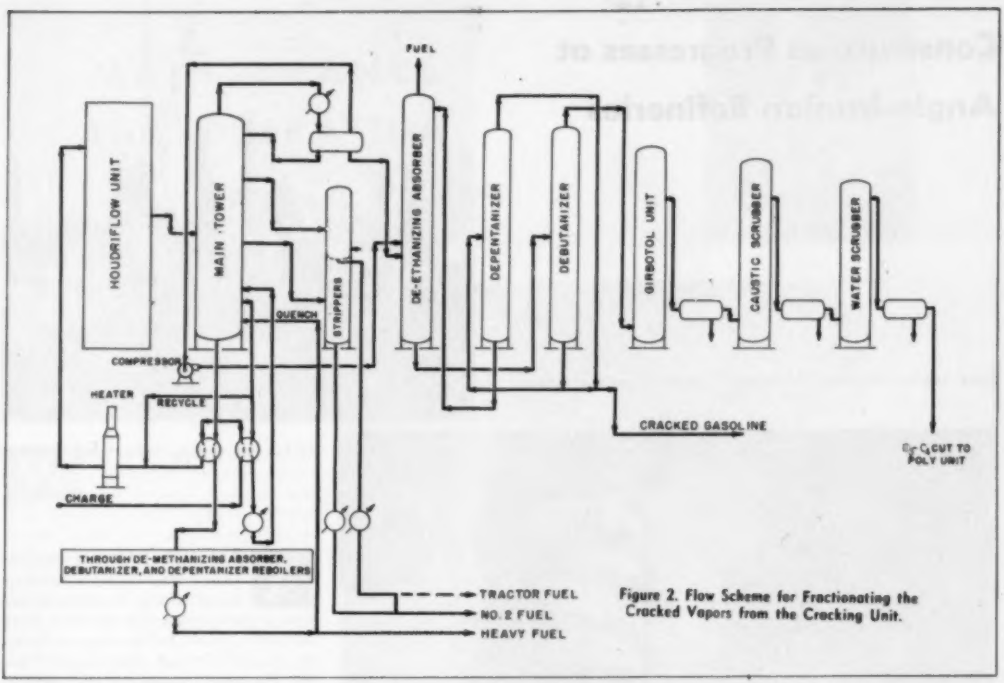


Figure 2. Flow Scheme for Fractionating the Cracked Vapors from the Cracking Unit.

The cracked oil is separated into five streams by the main fractionator as shown in Figure 2. The tractor fuel and No. 2 fuel oil streams are combined during winter months to be sold as No. 2 fuel oil. The overhead product from the tower is partially condensed while the light ends are compressed to be returned to the deethanizing absorber at a pressure of 225 psig. This tower, refluxed with a depentanized cracked gasoline, removes the ethane and lighter gases from the absorber feed to yield a bottoms product for charge to the debutanizer. A portion of the debutanized gasoline is depentanized to be used as absorption oil in the deethanizer. The debutanizer overhead, which is charged to a poly unit, is treated first in a Girbotol unit to remove hydrogen sulfide and then caustic washed for mercaptan removal.

Control

Nominal increases in the octane unmber of the finished gasoline may be made by raising the average reactor temperature. This can be accomplished by one or more of the following changes: increasing the charge preheat temperature, increasing the reactor catalyst inlet temperature by adjustment in the kiln burning conditions, and increasing the catalyst circulation rate.

The catalyst before and after regeneration is analyzed three times a week for carbon deposition. If the carbon deposition on the regenerated catalyst is too high, the air flow to the kiln may be increased and/or other kiln conditions may be adjusted to achieve the desired degree of regeneration of the spent catalyst.

Catalyst particle size is determined daily. If the average size decreases below 0.125 inches, the elutriator operation is adjusted by increasing the quantity of flue gas admitted to the classifier. The successful operation of the lift may be ascertained from the disengager hopper level; however, the operator also uses an auditory test through the use of a listening tube installed in the top of the hopper.

Operating Hints

Level Indicator

In addition to a level recorder on the catalyst disengaging hopper, the unit is provided with a hand-operated level indicator of the weight and cable type. The circulating catalyst eroded the cable to such an extent that the cable eventually broke. This problem was remedied by installing a pipe sleeve around the cable. The cable and weight are withdrawn into the sleeve when not in use.

Cooler Tube Bends

The original installation of the cooling section in the regenerator provided for rolled-tube return bends with plugs, which provided for easy cleaning. Due to mechanical failure of this type of construction, these bends were replaced with welded return bends.

Flue Gas Outlets

Originally, no control was provided for adjusting the relative amount of flue gas passing through each of the two zones in the kiln. Installation of a damper valve in the top outlet provides a method for adjusting the relative amount of burn-off above and below the cooling section.

Hopper Bed Gas

Catalyst is raised from the lift hopper to the disengaging hopper by means of two pressuring connections—one in an annular space around the lift pipe and one above the bed. Originally, steam was used above the bed; however, in order to achieve smoother control, the pressuring gas was changed to flue gas, as in the other connection. The lift hopper was also provided with a third pressuring connection at the bottom, but this connection is presently shut off.

Fresh Catalyst Feed

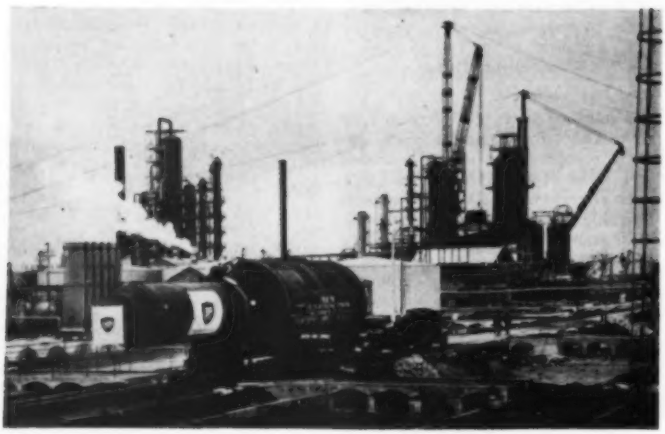
Originally, fresh catalyst was fed to the lift hopper by gravity. Presently, the catalyst is pressured by flue gas. The catalyst feed line is provided with a plastic window for visual observation of the flow.

Construction Progresses at Anglo-Iranian Refineries

Below: 460-Ton Distillation Column Under Construction at Kent Refinery, Isle of Grain.

65-Ton Fractionating Tower Being Erected at Llandarcy.

Below: 96-Ton Reactor for Grangemouth Cat Cracker.



AT ANGLO-IRANIAN Oil Company's Kent refinery, the main tower of the distillation unit now under construction has been erected and successfully passsed X-ray, pneumatic air and other tests. Plates for the tower were manufactured in the United States and shipped to the construction site where the tower was fabricated.

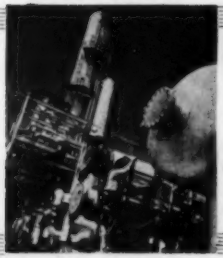
This is one of three AIOC modernization projects underway in the British Isles.

At Grangemouth, a 96-ton reactor, designed by Kellogg International has been delivered 20 miles by road to the catalytic cracking plant. The reactor is 76 feet long and has a maximum diameter of 16 feet.

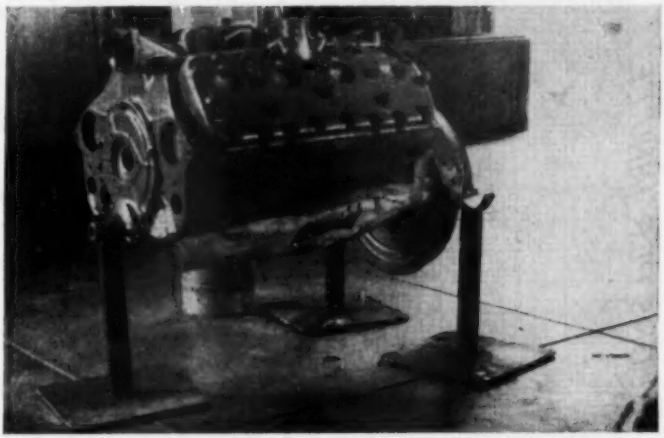
Towed by tug from Thames to Swansea, a fractionation tower for the new catalytic cracker, also designed by Kellogg International at the Llandarcy plant, weighs 65 tons, is 105 feet long with a diameter of 12 feet.

An electronically controlled refinery unit has been commissioned at Llandarcy. The unit is a plant for producing premium-grade kerosine and is now producing 500 tons per day on a designed capacity of 330 tons daily. Electronic measuring and control instruments are used exclusively in the plant for flow, pressure and level control. Operation is by electronic system which overcomes difficulties due to the distance between measuring points and the plant control room. This system eliminates lags due to compressibility of air in pneumatic controls, being virtually instantaneous, so any deviations in flow, pressure or level are detected and corrected instantaneously.

MAINTENANCE And OPERATION How To Do It—



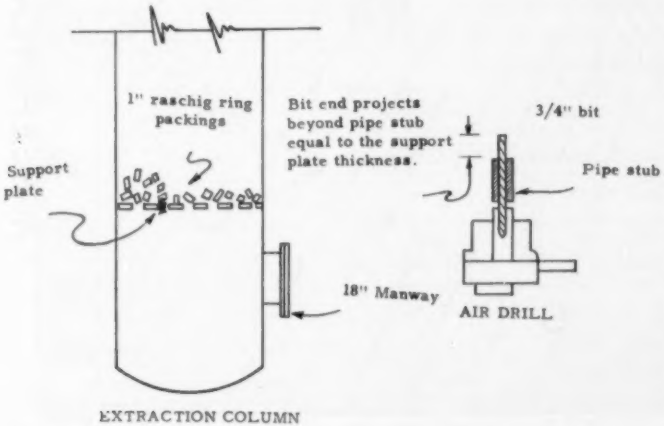
A Temporary Stand For Replacement Engine



WATER pumps driven by automotive type engines can be kept in service with little down time when the replacement "short block" is overhauled prior to setting in the base and hooking up.

Wilmington Gasoline Company, Wilmington, Cal., anticipates replacement, and provides the spare in condition to operate as soon as set into the base. Before replacement is required, this engine is brought into the building and set on temporary stands near the pump so it can be picked up easily and quickly by a crane. The open crankcase is protected by heavy paper attached to the unit with masking tape, or other convenient adhesive to keep the operating parts free of dust, etc. The stands are made by cutting short pieces of two-inch pipe and splitting the upper ends, after which these "prongs" are shaped to fit the end of the crankshaft, and the two side motor supports opposite the flywheel. Each post is welded to a large, heavy sheet of flat steel so the engine will rest in a secure position without danger of being overturned.

Increasing Capacity of Packed Columns



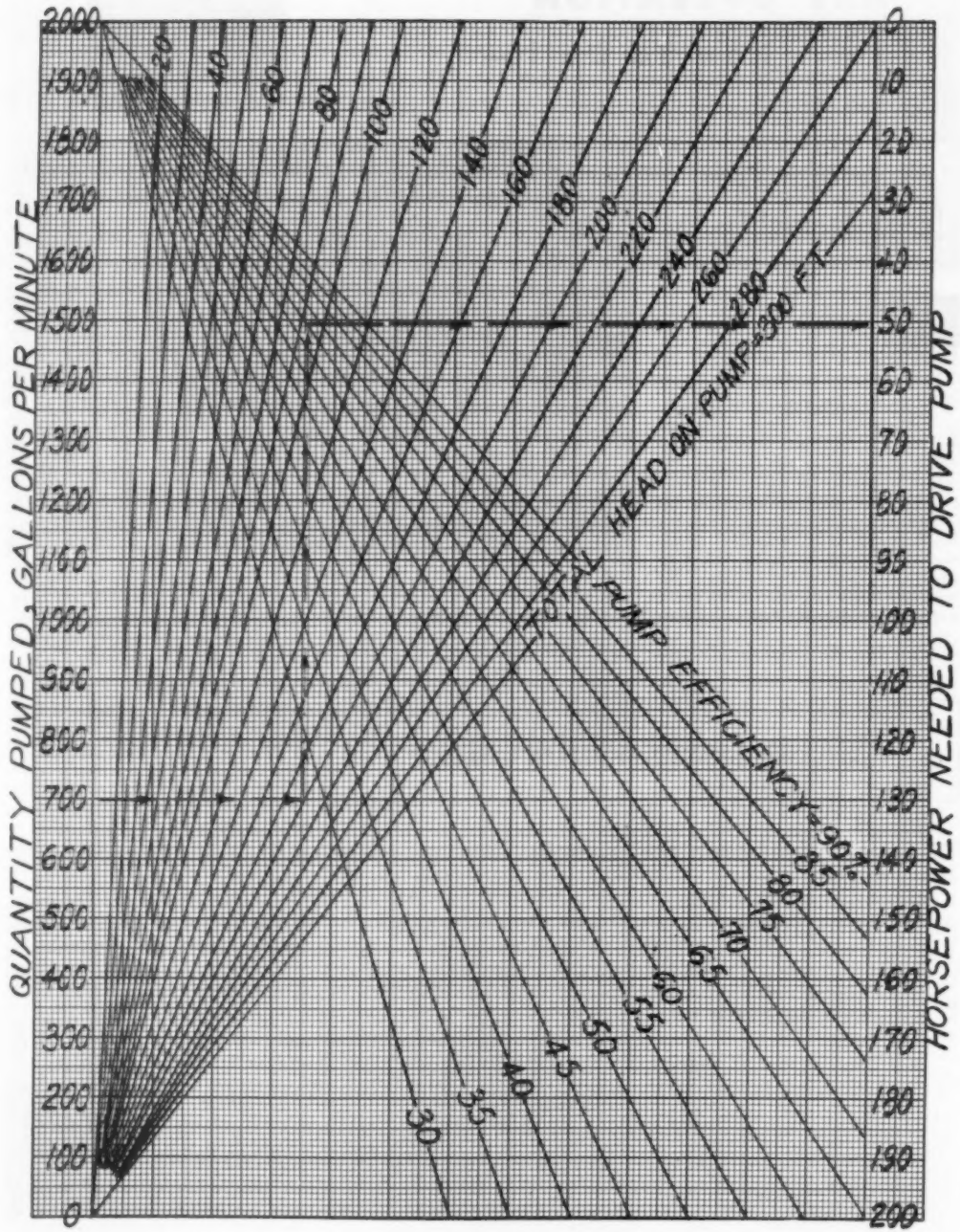
EXTRACTION COLUMN

IMPROPERLY designed packing support plates can hinder hydraulic flow in extraction columns. In one existing column which indicated that increased capacity could be achieved through redesign of the support plate, it was decided to increase the diameter of the holes from 3/8-inch on 1-inch centers to 3/4-inch in diameter.

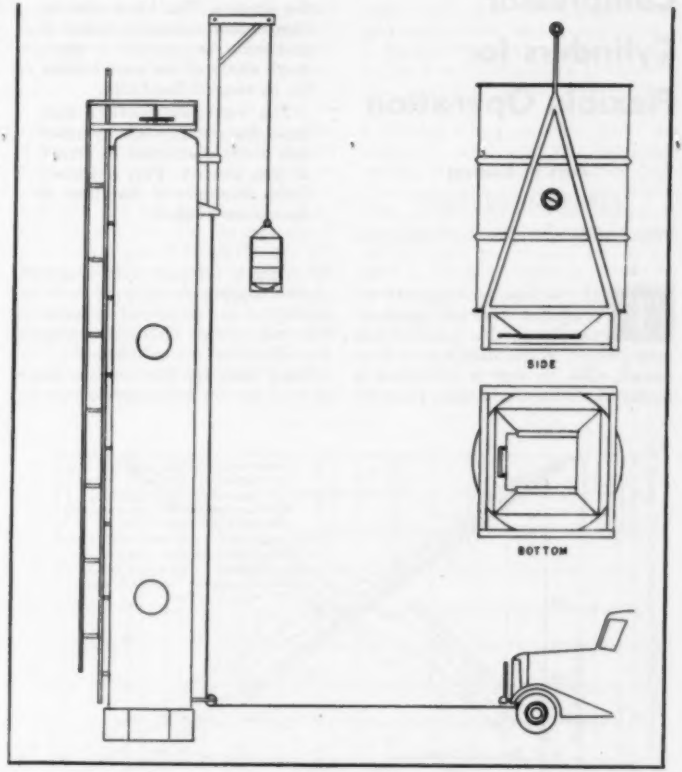
Normally, this change would have necessitated a tedious operation of unloading a tower full of 1-inch Raschig rings with some breakage of rings and with a high labor cost. After removing the rings, the bottom support plate would have been removed from the tower and taken to the repair shop for drilling the holes.

Instead of this time-consuming procedure, the holes were reamed out in place, from below, with all the packing in place. To insure that the bit penetrated the plate while not pulverizing the rings, a short piece of pipe was used as a stub as shown in the sketch.

Nomograph for Pump Horsepower



Desiccant Loading Apparatus



TO PROVIDE a fast, economical method of loading desiccant into the residue gas dehydrators, the apparatus shown was fabricated from a 55-gallon oil drum. The drum is altered by removing the top and providing a sliding trap door in the bottom for dumping the desiccant. The bottom of the drum is also sloped to insure that all of the desiccant falls through the 10 x 10-inch trap. the altered barrel is then placed in a hanger made of 2 x 2 x ¼-inch angle iron and welded in position. A drum rigged in this fashion will hold three 125 pound sacks of desiccant.

The loaded drum is hoisted into dumping position at the top of the tower by means of a cable threaded through the pulleys of a center-haul davit and attached to the frame of a truck. By driving the truck back and forth, the loaded drum can be quickly hoisted to the top, dumped and returned to the ground.

—O. F. Hamilton
Stanolind Oil & Gas Company
Andrews, Texas

NOTE

The maintenance and operation hint above is a prize winning "Operation Kink" from the Panhandle-Plains Regional Meeting of NGAA, Amarillo, Texas, November, 20 1951.

WHENEVER you select a pump to move oil, water, brine or other fluids in petroleum production you must know the horsepower needed to drive the pump in order to choose the driving motor or engine. If a characteristic curve for the pump is available, the required input horsepower can be found from it. However, the curve is not always on hand, especially if the pump is being transferred from an old location to another one. The accompanying chart simplifies pump calculations considerably and is useful to both petroleum plant designers and operators. Here's how it is used.

Example: A pump delivers 700 gpm of water against a total head of 200 feet of water. What power input is needed if pump efficiency under these conditions is 70 percent?

Solution: Enter at the left of the chart at 700 gpm and project horizontally to the sloping curve marked "Total head on pump = 200 feet." From the intersection project vertically to the 70 percent efficiency curve and then across horizontally to the right and read 50.4 horsepower.

Solutions obtained from the chart are suitable for water only. Where oils or other fluids that are lighter or heavier than water are pumped, horsepower obtained must be multiplied by the specific gravity of the fluid pumped.

Example: If an oil with a specific gravity of 0.84 (water at 60° F. = 1.0) were being pumped under the same conditions as in the above problem, what would be the horsepower input?

Solution: Solve the same as before. Then, horsepower needed to pump oil = 50.4 (0.84) = 42.3 hp.

Note that the horsepower found from the chart is not necessarily the same as the rated horsepower of the motor or engine chosen. For instance, in the oil pumping problem given above, a 50-hp motor would probably be chosen because there aren't any standard motors rated at 42.3 horsepower. Note also that total head on a pump is defined as the sum of the static, friction and velocity heads.

The chart is based on

$$P = \frac{gpm\ (H)(S)}{3960E}$$

where P = horsepower input
gpm = gallons per minute of fluid pumped
H = total head on pump, feet of liquid
S = specific gravity of liquid (water at 60° F. = 1)
E = pump efficiency, percent

This nomograph was prepared by T. G. Hicks, Hicksville, N. Y.

MAINTENANCE And OPERATION

How To Do It–

Compressor Cylinders for Flexible Operation

Part II: Control

ROBERT S. RIDGWAY

Standard Oil Company of California

WHEN BUYING new compressors, the cylinders can be selected to meet the immediate condition; or by careful planning, they can often be chosen with sufficient flexibility to follow a considerable pressure decline and still load the engine. The high cost of compressor cylinders makes it profitable to conduct a thorough study of the possibilities for increased flexibility.

The various factors that limit the compressor cylinder size were discussed in Part I of this series. Part II shows some examples of the effect of clearance control.

THE horsepower required to compress natural gases of various specific gravities has been pretty well established, or at least agreed upon so that it is seldom a matter of controversy. Curves are readily available for such work. However, curves showing the horsepower required for any particular cylinder, as the suction and discharge pressures are varied, are not so standard.

Many years ago this company began plotting its own horsepower curves for each particular cylinder in a form which best suited its needs. As time went on information was added to this curve, until today there is a very useful set of data which aids materially in selecting cylinders and the clearance which should be applied. As a final check in new layouts, the computation is usually made for the volume thruput and load but for field work, for making the initial choice of cylinder, and for the plant operator in effecting his control, the curves are sufficiently accurate to give good results and save a tremendous amount of computing time.

On one line of cylinders which are equipped with two clearance passages, three such curves are prepared for each cylinder; one with standard clearance, one with standard plus 10 percent additional, and a third with standard plus 20 percent additional. Quite close interpolation is then possible.

Figures 1, 2, and 3 show a typical set of curves on a 15-inch x 14-inch lined cylinder. Suction pressures are shown as the abscissae, discharge presures are the curved lines which cross the ratio of compression lines. The latter all emanate from the 0-psia point. Horsepower is shown as the ordinate. At the top of the sheet, the gas volumes are shown by plotting the discharge pressures against the same abscissae of intake pressure, showing the volume throughput as an ordinate. This curve is particularly convenient when calculating load and capacity due to changes in operating pressures.

By the use of the supplementary curves, the required clearance change to maintain load can be readily calculated. In the upper left corner of these curves will be noted a small plot to show how many cubic inches of additional clearance is required to effect a definite *percent* of clearance. The notes carry the relationship and show that 1 percent = 48.92 cu. in. However, the cylinder in question is equipped with two throats and two separate external pockets can be attached. This "pocket" curve also indicates the percent clearance contained in each throat. From it we can see that the replacement of one plug with a blind plate will increase the total cylinder clearance by 1 percent. The same procedure on the other throat will double the percent clearance. Adding clearance on one end, while keeping the opposite throat plugged, alters the total percent clearance of the total cylinder, as shown by the lower curve. When a single pocket becomes unwieldy or two are desired in any event, the upper curve shows the relation between the total percent clearance

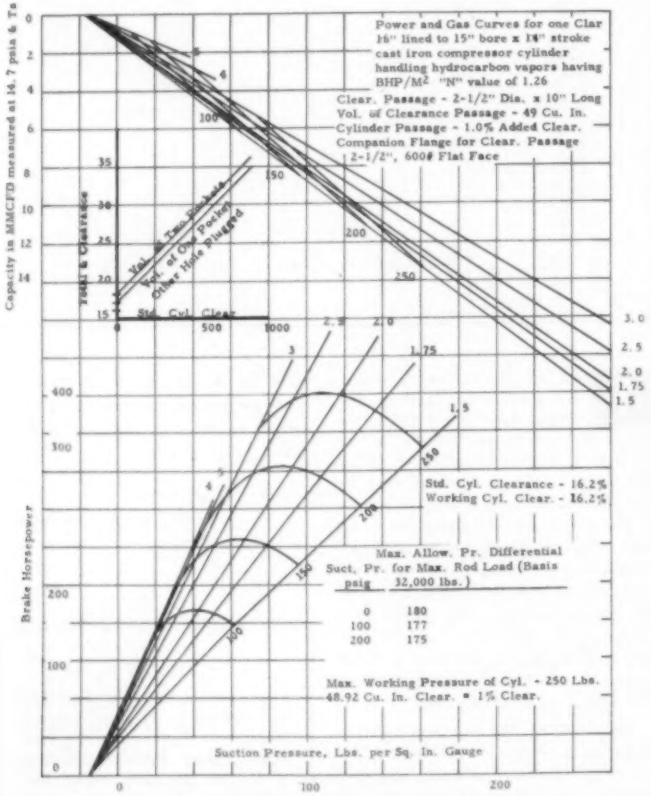

Power and Gas Curves for one Clar
16" lined to 15" bore x 14" stroke
cast iron compressor cylinder
handling hydrocarbon vapors having
BHP/M² "N" value of 1.26
Clear. Passage - 2-1/2" Dia. x 10" Long
Vol. of Clearance Passage - 49 Cu. In.
Cylinder Passage - 1.0% Added Clear.
Companion Flange for Clear. Passage
2-1/2", 600# Flat Face
Total % Clearance
Std. Cyl. Clear.
Value if Two Throats
End of One Pocket
Other Hole Plugged
Capacity in MMCFD measured at 14.7 psia & Ts
Brake Horsepower
Suction Pressure, Lbs. per Sq. In. Gauge
Std. Cyl. Clearance - 16.2%
Working Cyl. Clear. - 16.2%
Max. Allow. Pr. Differential
Suct. Pr. for Max. Rod Load (Basis 32,000 lbs.)
psig
0 180
100 177
200 175
Max. Working Pressure of Cyl. - 250 Lbs.
48.92 Cu. In. Clear. = 1% Clear.

Figure 1. Power and Gas Curves for 15 x 14 Cylinder with 16.2 Percent Clearance.

and the combined volume of the two pockets.

The important feature is that the throat clearance has been taken into account in preparing this curve. The very marked effect of clearance or capacity and horsepower is readily seen from comparing these curves on the same cylinder with different clearances. Horsepower curves are of best value when they supply all the necessary information which will be needed in computations. This one, it is believed, fulfills this function, and can be recommended as being exceedingly useful.

The solution of some typical problems may illustrate how clearance control may be of value to an oil field compressor station.

Several years ago in one operating area, the company was faced with the problem of attempting to maintain rated load on compressors in face of varying intake pressures and relatively stable discharge pressures. Over periods of time the normal field decline had been causing a reduction in trap pressures, resulting in declining suction pressures. From day to day, however, the addition or removal of wells in operation coupled with the fixed capacity had made fairly wide local pressure changes. Due to such changes, it was found necessary to work out some method of relieving the load during the period of high suction pressures, yet retaining the ability to pull the pressure down for the benefit of producing operations whenever possible.

Clearance pockets were the logical answer to this problem. The cylinders on the units involved had no provision for internal pockets, and to purchase heads with pockets or to develop heads with throats would have been quite expensive. To care for this problem, it was found that the existing indicator holes could be enlarged to ¾-inch (pipe size) and new ones could be drilled on the side of the cylinders opposite to those already installed. This afforded the opportunity to have four pockets on each cylinder. The many small pockets lent themselves ideally to maintaining rated load on the unit through small increments, as the curves will show.

It was decided to have the pockets made from hemispherical welding caps, as this shape gave maximum strength, involved a minimum space for the volume content, required the least fabrication, and used readily available material. Most of these caps are made with a short skirt, which, cut off at any desired length, provided the overlap of capacity which is necessary between caps of various nominal pipe sizes. Figure 4 shows the standard print which was issued to the shop doing the work. Blanks were merely filled in to get the sphere desired. Using the API-ASME code for calculating the allowable pressures, these spheres were found to be far above requirements for pressure. Each sphere was hydrostatically tested to 1½ times its working pressure and the test pressure, the working pressure, and volume in cubic inches were stencilled on the pocket.

In mounting such pockets, it is essential that they stand upright with the pipe connection on the bottom so that no lubricating oil will collect inside and thus decrease the effective capacity. For this reason, it is necessary to make sure that the pipe nipple does not project through the cap any farther than necessary to make the inside weld. If these pockets must be mounted vertically, then it is desirable that an angle valve be used. One that will give full flow with the least restriction when open is highly desirable for this position.

These installations have been particularly satisfactory. More than 150 of these spherical pockets have been made up at very nominal cost. Their performance has been as calculated.

An application of such type of control to a unit is illustrated in Figure 5. The installation consisted of a 300-hp 4-cycle, v-angle compressor equipped with three 6-inch cylinders. Three 44-cubic-inch and one 22½-cubic-inch pockets were installed at four indicator connections as shown on the diagram in the figure. These pockets do not have to be arranged in this manner to effect the desired result, but are convenient to reach as shown. By having the small and large pocket increments, the maximum deviation from a full load is only plus or minus 5 hp., with a variation of intake pressure from 121½ pounds to 175 pounds. If no pockets were on this unit, it

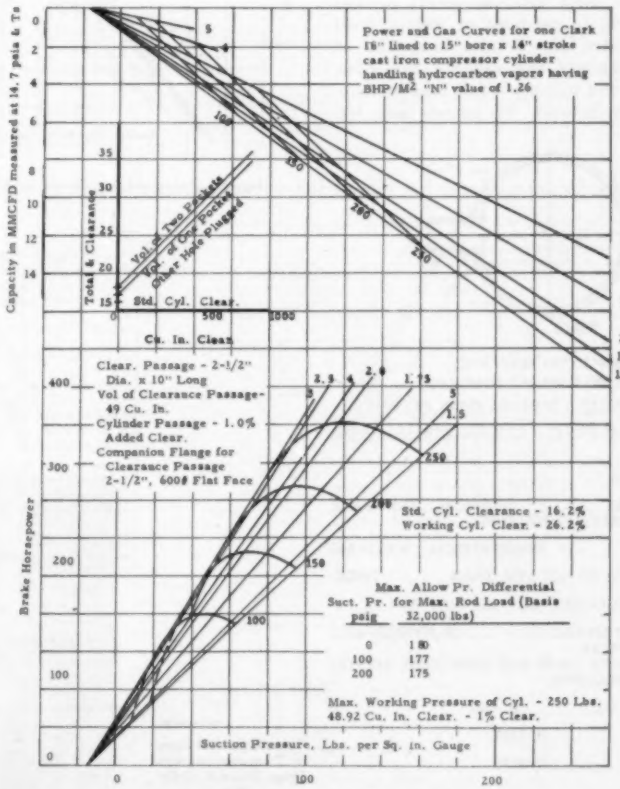
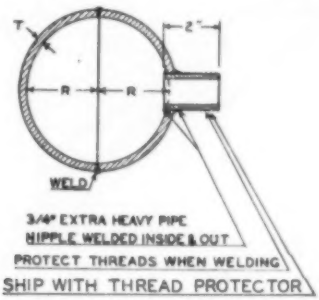

Power and Gas Curves for one Clark
15" lined to 15" bore x 14" stroke
cast iron compressor cylinder
handling hydrocarbon vapors having
BHP/M² "N" value of 1.26
Capacity in MMCFD measured at 14.7 psia & To
Brake Horsepower
Total % Clearance
Vol of Two Pockets
or One Pocket
Other Hole Plugged
Std. Cyl. Clear.
Cu. In. Clear.
Clear. Passage - 2-1/2"
Dia. x 10" Long
Vol of Clearance Passage-
49 Cu. In.
Cylinder Passage - 1.0%
Added Clear.
Companion Flange for
Clearance Passage
2-1/2", 600# Flat Face
Std. Cyl. Clearance - 16.2%
Working Cyl. Clear. - 26.2%
Max. Allow Pr. Differential
Suct. Pr. for Max. Rod Load (Basis
psig 32,000 lbs)
0 180
100 177
200 175
Max. Working Pressure of Cyl. - 250 Lbs.
48.92 Cu. In. Clear. - 1% Clear.
Suction Pressure, Lbs. per Sq. in. Gauge

Figure 2. Power and Gas Curves for 15 x 14 Cylinder with 26.2 Percent Clearance.

would be overloaded by 51 hp. at 175 pounds. If a valve lifter were to be installed to open one of the intake valves instead of using pockets, the relief of one end of one cylinder is roughly 50 horsepower, which is an increment far too large to prevent losses at "in between" pressures. On this installation, the four pockets provide seven increments. The gas capacity of this unit for any of the conditions is indicated by the lower curve of the two. For convenience, a key letter has been placed opposite each pressure range covered by any setting, and at the bottom of the sheet a table shows the position of all of the pockets corresponding to any of these key letters.

Figure 6 is for a condition greatly similar to the one shown previously. On this 260-hp. unit, there are four cylinders of two different sizes, all operating in parallel. Again there are three large and one small pocket which, in combination with a small cylinder, provide nine increments of horsepower and capacity and allow the unit to carry a full load by 5-hp. steps between 95 pounds and 165



DATE _____

MAKE _____ SPHERICAL CLEARANCE POCKETS AS FOLLOWS:

USE _____" HEMISPHERICAL WELDING CAPS, OF NOT LESS THAN _____" THICK, ACCURATELY CUT SO THAT R = _____"

TEST SPHERES TO _____ LB. HYDROSTATIC PRESSURE
STENCIL EACH ONE WITH STEEL LETTERS AS FOLLOWS:

VOL. _____ CU. INS.

_____# TEST

_____# W.P.

Figure 4. Fabricating Print for Spherical Pocket.

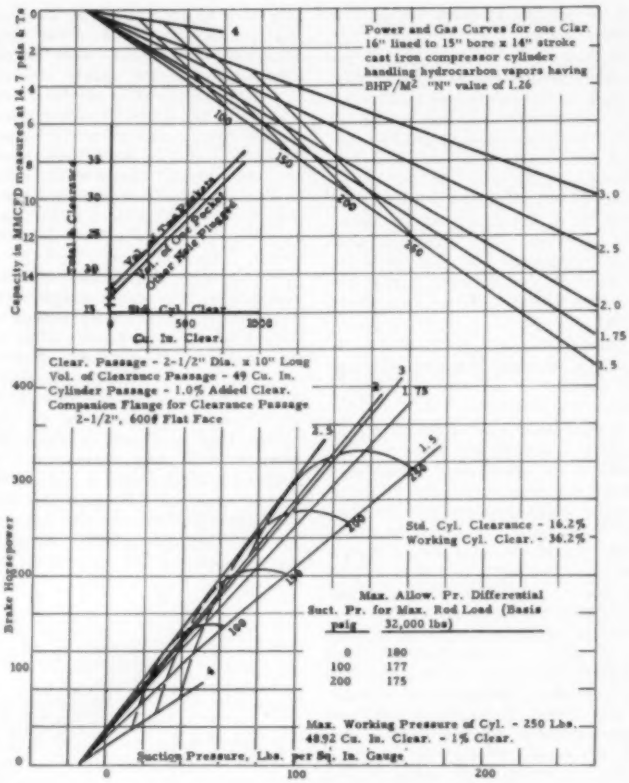
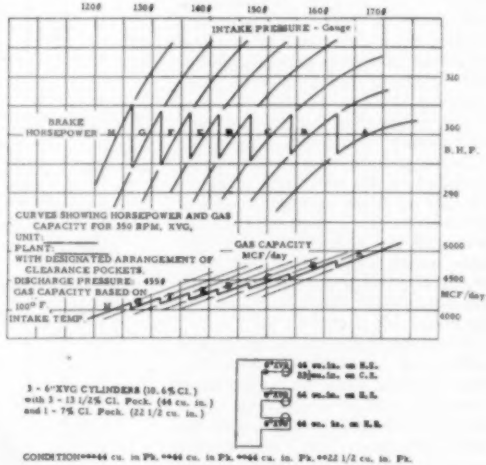

Power and Gas Curves for one Clar. 16" lined to 15" bore x 14" stroke cast iron compressor cylinder handling hydrocarbon vapors having BHP/M² "N" value of 1.26
Capacity in MMCFD measured at 14.7 psia & To
Brake Horsepower
Clearance
Std. Cyl. Clear.
Cu. In. Clear.
Clear. Passage - 2-1/2" Dia. x 10" Long
Vol. of Clearance Passage - 49 Cu. In.
Cylinder Passage - 1.0% Added Clear.
Companion Flange for Clearance Passage
2-1/2", 600# Flat Face
Std. Cyl. Clearance - 16.2%
Working Cyl. Clear. - 36.2%
Max. Allow. Pr. Differential
Suct. Pr. for Max. Rod Load (Basis 32,000 lbs)
psig
0 180
100 177
200 175
Max. Working Pressure of Cyl. - 250 Lbs.
48.92 Cu. In. Clear. - 1% Clear.
Suction Pressure, Lbs. per Sq. In. Gauge

Figure 3. Power and Gas Curves for 15 x 14 Cylinder with 36.2 Percent Clearance.



3 - 6"XVG CYLINDERS (10.6% Cl.)
with 3 - 13 1/2% Cl. Pock. (44 cu. in.)
and 1 - 7% Cl. Pock. (22 1/2 cu. in.)
44 cu. in. or S.E.
44 cu. in. or S.E.
44 cu. in. or S.E.
CONDITION 44 cu. in Pk. 44 cu. in Pk. 44 cu. in. Pk. 22 1/2 cu. in. Pk.

A	OPEN	OPEN	OPEN	OPEN
B	OPEN	OPEN	OPEN	CLOSED
C	OPEN	OPEN	CLOSED	OPEN
D	OPEN	OPEN	CLOSED	CLOSED
E	OPEN	CLOSED	CLOSED	OPEN
F	OPEN	CLOSED	CLOSED	CLOSED
G	CLOSED	CLOSED	CLOSED	OPEN
H	CLOSED	CLOSED	CLOSED	CLOSED

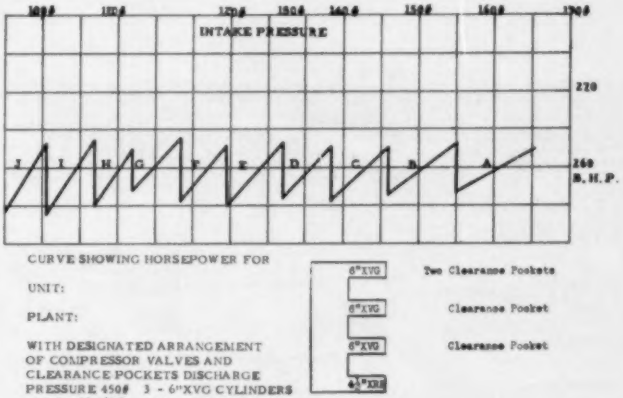
Figure 5. Control Curve for Compressor with Three Six-Inch Cylinders.

pounds intake pressure. The discharge pressure is constant at 450 pounds. In this particular installation a condition has been reached where it is necessary to remove a valve from one end of a 6-inch cylinder. If the intake pressure is to cross this mark frequently, then a valve lifter should be provided so that this valve can be taken out of service on the run. Otherwise, if the pockets are merely provided to care for a condition anticipated under normal field decline, it may be possible to shut down to remove such a valve without too much loss to the plant. The machine in question is shown in Figure 7.

Figure 8 illustrates a rather interesting control curve. The unit which it covers is a 260-hp. 4-cycle, v-angle compressor and is equipped with two 6-inch cylinders which take suction at pressures which may vary from 110 pounds to 160 pounds. The discharge from these cylinders is fixed at 450 pounds. A part of this gas is intercooled and goes to a gas lift service cylinder at 435 pounds. A 3⅞-inch cylinder boosts this gas to gas lift pressures, which may vary from 800 pounds to 1200 pounds. It is desired to let the gas lift cylinder handle as much as it will and regulate the low-stage cylinders to maintain maximum horsepower on the unit. One 13½ percent and one 7 percent pocket are placed anywhere on the low-stage cylinders. Reading up from the existing gas lift discharge pressures shown on the curve to the reduced high-pressure intake pressures shown as ordinates, the proximity to lines A, B, C, and D shows the position of the valves under the pockets to keep the compressor loaded.

The examples shown above may not be too common in gasoline plant operation, but present a rather striking example of the flexibility offered by pockets when operating conditions are benefitted therefrom. The engineers entrusted with the selection of compressor equipment will do well to make sure that the cylinders which they specify are equipped to provide the utmost in flexibility.

End of Part II and series.



Condition-13 1/2% pocket-13 1/2% pocket-13 1/2% pocket-7% pocket --

					Notes
A	OPEN	OPEN	OPEN	CLOSED	Inlet valve out of frame end one 6"XVG Cylinder
B	OPEN	OPEN	OPEN	OPEN	"
C	OPEN	OPEN	CLOSED	CLOSED	"
D	OPEN	CLOSED	CLOSED	OPEN	"
E	OPEN	CLOSED	CLOSED	CLOSED	"
F	CLOSED	CLOSED	CLOSED	OPEN	"
G	CLOSED	CLOSED	CLOSED	CLOSED	"
H	OPEN	OPEN	CLOSED	CLOSED	All inlet valves operating
I	OPEN	CLOSED	CLOSED	OPEN	"
J	OPEN	CLOSED	CLOSED	CLOSED	"

Figure 6. Control Curve for Compressor with Four Cylinders, Four Pockets and One Valve Lifter.

Figure 8. Control Curve for Compressor with Cylinders on Two Different Gas Services.

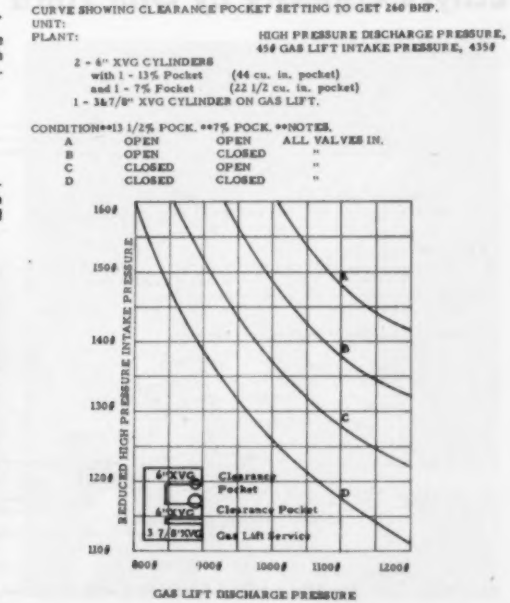
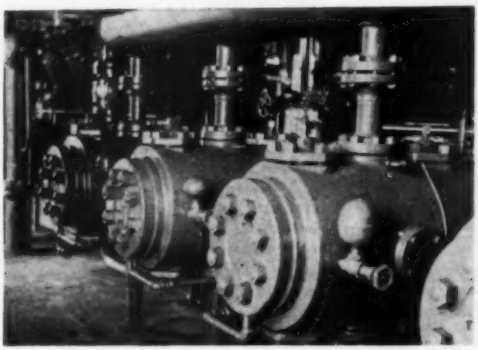
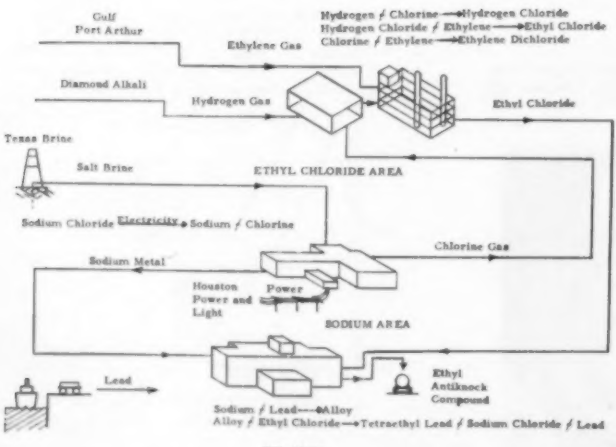


Figure 7 (below). Compressor Cylinders with Valve - Controlled Pockets.



The Ethyl Corporation's new plant on the Houston Ship Channel is rapidly being completed and is about to begin production. The "golf ball on its tee," upper right, is a 100,000-gallon water tower.

TEL Plant Completion Increases Ethyl's Capacity by One Third



How Ethyl Antiknock Compound Is Made in Houston.

TETRAETHYL lead, the primary constituent in antiknock compounds, is the major product of Ethyl Corporation's new plant, located along the south bank of the Houston Ship Channel, about 17 miles from downtown Houston. The process intermediates, sodium, chlorine and ethyl chloride, will also be marketed.

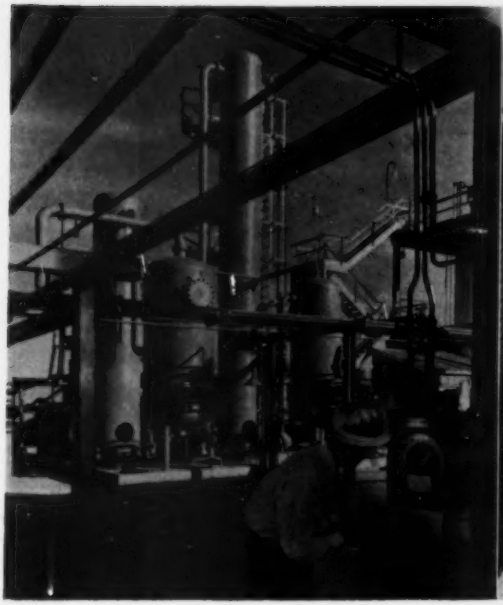
With a predicted production of 80 million pounds per year, the Houston plant increases Ethyl Corporation's capacity to produce antiknock compounds by approximately one-third. Basically, the plant is divided into three major operating areas—the sodium area, the ethyl chloride area, and the tetraethyl lead area. In addition, it has an administration building, a shops and stores area, a storage tank area, a utilities area, and other auxiliary facilities.

Sodium Area

The principal structure here is the T-shaped sodium building. Salt is electrolytically decomposed into sodium and chlorine. In one section of the building, incoming salt brine is evaporated, filtered and dried prior to being decomposed. The other section contains the cell room, where the salt is fed into two batteries of sodium cells and electrolyzed.

Ethyl Chloride Area

Ethyl chloride is produced by the reaction of hydrogen chloride with



The unit shown here drives hydrogen chloride gas, one of the intermediate chemicals needed for anti-knock compound manufacture.

This 90-foot reactor will make ethyl chloride from ethylene and hydrogen chloride.

ethylene. The first unit to participate in the process is the hydrogen chloride plant, which contains six burners. Hydrogen is burned with the chlorine obtained from the sodium operations. The resultant hydrogen chloride is then transferred to the compressor house, containing four compressors, where it is compressed. The hydrogen chloride then passes to the ethyl chloride unit, where it is reacted with ethylene to form ethyl chloride. Another unit in this area is the ethylene dichloride plant, where ethylene is added to chlorine to form ethylene dichloride.

Tetraethyl Lead Area

This is where the basic tetraethyl lead manufacturing operation is conducted by the reaction of ethyl chloride with a lead-sodium alloy. In the alloying operations, metallic lead is reduced to its molten state and is then combined with molten sodium to form an alloy. The tetraethyl lead section of the building is four stories high. The manufacturing operation begins on the fourth floor, where the lead-sodium alloy and the ethyl chloride are introduced. The basic tetraethyl lead reaction takes place inside this building. Also located in this building is the equipment where tetraethyl lead is washed and purified and then blended with other ingredients (ethylene dichloride, ethylene dibromide, and dye) to form the finished antiknock compound.

The plant's principal raw materials include pig lead, salt brine, hydrogen, ethylene, natural gas, sulfuric acid and ethylene dibromide. With the exception of pig lead, which is purchased from domestic and foreign producers, the plant will obtain all of these raw material requirements from nearby sources in Texas.

This huge revolving oven will dry sodium chloride, one of the chemicals required in manufacturing tetraethyl lead.

1st An Aerial View Showing Entire Plant of Panoma Corporation, Hooker, Okla. Tank car loading rack in foreground.

Panoma Plant Favors Intermediate Separation Over Consecutive Topping

I. EARL NUTTER

Panoma Corporation, Amarillo, Texas

AN EXAMPLE OF modern practice in the fractionation of light hydrocarbons is disclosed through this description of Panoma Corporation's gasoline plant located in almost the geographical center of Oklahoma's Panhandle. An economic study of two sequences of fractionation revealed that the method of separating groups of products and then separating the binary mixtures was preferable to the method of consecutively removing the products in order of their volatility.

THE HOOKER gasoline plant processes gas from 120 dry gas wells with each on a full section (640 acres) lease. The company gathers the gas under natural pressure and delivers it to the gas purchaser at the purchaser's booster station adjacent to the plant. The gas is presently received by the purchaser at about 275 pounds gauge and boosted to 680 pounds and delivered to Panoma Corporation's plant fence where it is processed and returned to the custody of purchaser beyond a block valve in the same line from which it was received for processing. The sale of gas to the purchaser occurs about 1000 feet beyond this point at purchaser's metering station.

Panoma's contract with purchaser in part provides that purchaser shall boost the gas pressure sufficient to enter purchaser's main gas pipe line some 30 miles distant before delivery to Panoma for processing, that the price of the gas shall be based on a 965 Btu dry determination with the price increased or decreased proportionate to 965 Btu but below 960 Btu the price shall be further reduced ten percent, that Panoma shall operate a dehydration plant and reduce the gas to a maximum dew point of 25° F., and that purchaser shall boost all gas used for fuel and lost by extraction shrinkage without compensation. A later tentative agreement permits Panoma to process the fuel used by purchaser with purchaser being supplied from the main residue gas header leaving the plant.

In view of these desirable conditions, briefly related, and the relative permanency of a plant based on estimated gas reserves, this entire plant was designed for a minimum of maintenance, operating labor needs, fuel consumption and maximum flexibility in marketing possibilities of products produced. Table 1 is an early evaluation of the analysis of the gas entering the plant and the charge stock to the fractionation system expressed in mols and gallons per hour.

This volume of charge stock to the fractionators used for design, is that obtainable from processing 100 million cubic feet daily @ 14.65 pound measurement of the analysis shown plus the recovery of 26-pound Reid vapor pressure product only from an additional volume of 40 million cubic feet of higher nitrogen content and with the reduction of the aggregate volume of 140 million cubic feet to 965 Btu. The composition of the charge to the fractionators results from employment of a rich oil de-ethanizer in the distillation system with the vapors therefrom passed through a reabsorber in the lean oil stream to the

Original presentation as "Trends in Fractionation" was at the 31st annual convention of the Natural Gasoline Association of America, May 1, 1952, Houston.

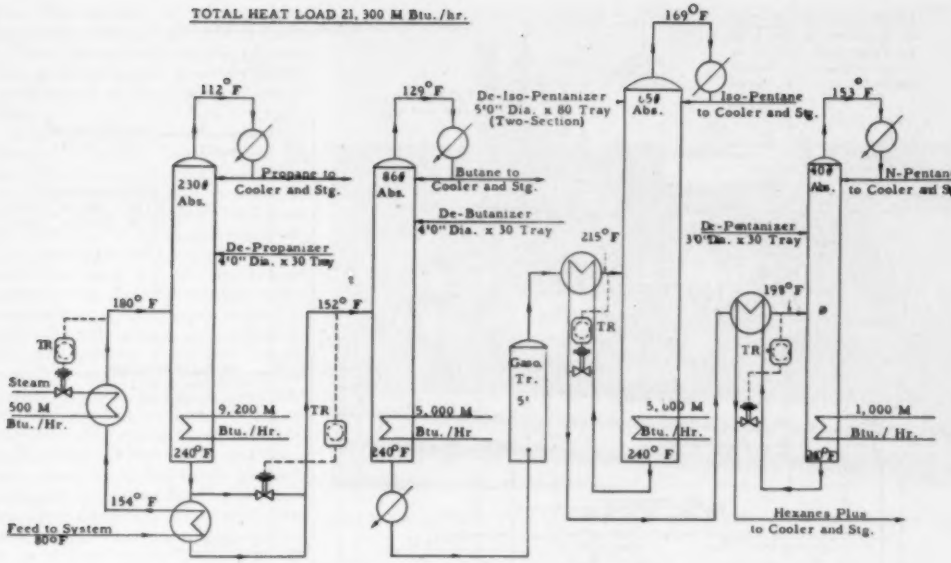


Figure 1. Fractionation by Consecutive Topping.

main absorber to support the Btu of the residue gas and permit maximum recovery of products for a given Btu of the residue gas. Residue vapors from this re-absorber has a Btu of 1015, contains about 10 percent ethane and 0.3 percent propane, and supplies 80 to 90 percent of the entire plant fuel requirement.

The fractionation requirement is to produce relatively high purity propane, butanes (iso and normal mixture), iso-pentane, normal-pentane and hexanes plus. There was no particular desire to remove all of the normal-pentane from the hexanes plus but in present operation while producing good purity normal-pentane it is possible to remove any portions of the normal-pentane desired up to a purity of about 98 percent hexanes plus.

A study of two sequences of fractionation to accomplish these separations of products was made. One method considered was to consecutively remove the products in the order of their volatility and the other method to first separate groups of products and finally separate bi-nary mixtures. This latter method was found to be more economically advantageous in several respects. Figure 1 represents the method of consecutively removing the products in the order of volatility. In this method an over-all heating load of 21,300,000 Btu per hour was required which would also require a cooling load for the reflux condensers of a reasonable approach to the same amount. The re-boiler temperatures of two of the heavy duty units had to be in the range of 240° F. in order to result in sufficiently high enough overhead temperature to effectively condense reflux with the available cooling water temperature. The other two units though represented differently could have been operated at lower reboiler temperatures, where lower grade exhaust steam could be used, with satisfactory overhead temperatures. However, had this been done, less utilization of heat-exchangers, which was already poor, could have been realized and the result would have been the use of additional quantities of steam.

TABLE 1

Natural Gas and Fractionator Feed Quality

COMPONENTS	DESIGN ANALYSIS AND YIELD @ 14.65 Mol. Pct.	GPM @ 14.65	FRACTIONATOR CHARGE STOCK Mols./Hr.	Gals./Hr.
Carbon Dioxide	0.20	....	....	....
Nitrogen	12.25	....	....	....
Methane	74.91	....	....	....
Ethane	6.57	....	2.0	19
Propane	3.88	0.4237	145.0	1511
Iso-butane	0.39	0.1196	49.0	607
Normal-butane	1.10	0.3376	151.0	1900
Iso-pentane	0.18	0.0708	28.0	389
Normal-pentane	0.20	0.0720	31.0	426
Hexane plus	0.32	0.1304	49.8	833
Total	100.00	1.1541	455.8	5585

TABLE 2

Tower Sizes and Hourly Volumes

	De-propanizer	De-butanizer	De-I-pentanizer	De-N-pentanizer
A. Sequence of Topping in Order of Volatility (Figure 1)				
Tower Size	4' 0"	4' 0"	5' 0"	3' 0"
No. Trays	30	30	80	30
Working Press. lbs. abs.	230	86	65	40
Mols/Hr. Feed	455.8	308.8	107.1	79.8
Mols/Hr. O. H. Product	**146.0**	**202.7**	**26.3**	**39.7**
Mols/Hr. Base Product	308.8	107.1	79.8	50.1
Mols/Hr. Reflux	999.3	437.8	641.7	67.5
Reflux/Overhead	6.09/1	2.16/1	24.40/1	2.20/1
Reflux/Base	2.88/1	4.09/1	8.04/1	1.35/1
B. Sequence of Intermediate and Bi-nary Operation (Figure 2)				
Tower Size	3' 6"	3' 6"	4' 0"	3' 0"
No. Trays	35	35	80	35
Working Press., lbs. abs.	250	120	30	25
Mols/Hr. Feed	348.7	455.8	57	107.1
Mols/Hr. O. H. Product	**146.0**	348.7	**24.3**	57
Mols/Hr. Base Product	202.7	107.1	33.7	50.1
Mols/Hr. Reflux	419.0	502.0	233.0	82.0
Reflux/Overhead	2.87/1	1.70/1	8.47:1	1.44/1
Reflux/Base	2.07/1	8.53/1	7.28:1	1.64/1

Blackface items represent finished product.

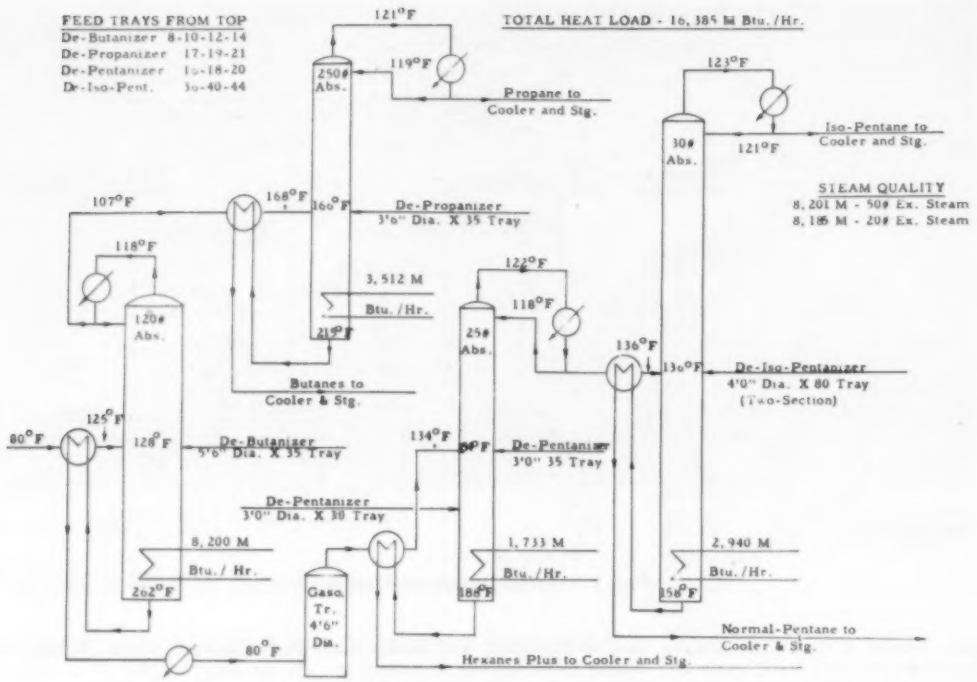


Figure 2. Fractionation by Intermediate Separation.

The sequence of fractionation selected is shown in Figure 2. Though three of the units have been increased to 35 tray towers over 30 trays in the other sequence, the heat load required is 16,385,000 Btu per hour, and is only 77 percent of the heat load used in the other sequence of operation. Good utilization of heat exchangers is realized because, in the system as a whole, the volumes of base stocks are in better proportion to the feed stocks and the heat exchangers are smaller because the volumes handled are less. About half of the steam required for the re-boilers is 50-pound exhaust and the balance is 20-pound exhaust thus permitting better water rates on steam operated mechanical drive turbines used in other areas of the plant. The overhead vapor temperatures are all satisfactory for good condensing conditions yet sufficiently low to prevent any troublesome fouling with scale from the cooling water. A comparison of some of the tower specifications and volumes of streams of these two sequences of fractionation, for the charge stock shown in Table 1, and products to be produced are shown in Table 2. The total mols of reflux in the topping sequence is 2036 per hour as compared with 1326 in the latter. This is a reduction of 710 or 34.8 percent in the mols reflux over the requirement in the topping sequence. The total volume of the towers in the tray sections is 5074 cubic feet in the topping sequence as compared to 4842 in the latter. This is about a five-percent reduction.

The desired composition of products to be produced under design conditions are shown in Table 3. Here the purities of propane, butanes and hexanes plus are about 98 percent and iso and normal pentane are about 95 percent. Actually the 40 million cubic feet of gas daily, from which only a 26-pound product was to be extracted, was not obtained for processing, however a volume of 26-pound natural gasoline equivalent to this volume of production is being purchased and with the plant processing the 100 million cubic feet daily, a volume of feed stock equivalent to design volume is being fractionated and iso and normal pentane in the order of 98-percent purity is produced. During winter months, when propane is in much greater demand than butanes, propane in the order of 0.60 to 0.65 gallons per thousand cubic feet of gas of better than 98-percent purity has been consistently produced, with a portion of the butanes returned to the gas in the lean oil stream to the absorbers to support a minimum of 960 Btu on the residue

TABLE 3
Composition of Products Produced

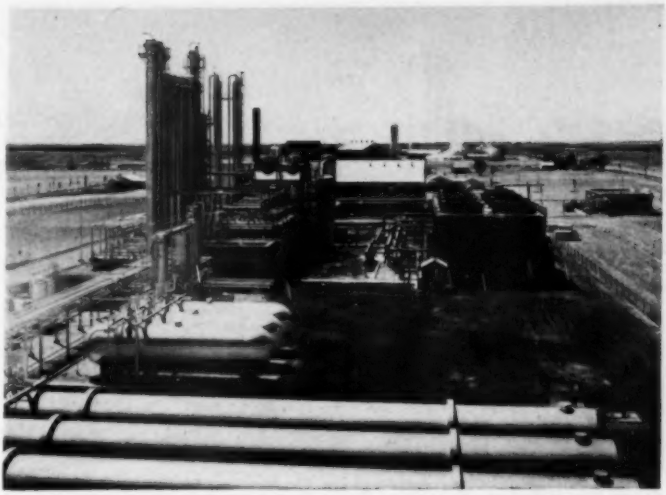
Components Percent	Propane		Butanes		Iso-Pentane		N-Pentane		Hexanes Plus	
	Mol.	Liq. V.	Mol.	Liq. V.	Mol.	Liq. V.	Mol.	Liq. V.	Mol.	Liq. V.
Ethane	1.37	1.25								
Propane	97.95	97.96	0.99	0.86						
Iso-butane	0.68	0.79	23.68	24.38						
Normal-butane			74.34	83.72	1.14	0.82				
Iso-pentane			0.99	1.14	95.06	95.33	3.26	3.31		
Normal-pentane					3.80	3.85	94.46	94.09	2.00	1.67
Hexanes plus							2.28	2.60	98.00	98.33
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Product Purity	97.95	97.96	98.02	98.10	95.06	95.33	94.46	94.09	98.00	98.33

gas. This recovery of propane compares with about a 0.42 yield in Table 1. Thus, the system is capable of more than meeting design product purity specifications at design load conditions.

A detail of the pentane-splitter is shown in Figure 3. The schematic arrangement and instrumentation of the other three fractionation systems are the same as for this system. Feed from the discharge of the de-pentanizer reflux pump metered by a rate of flow controller re-set by the liquid level controller on the de-pentanizer reflux accumulator is introduced at one of three alternate entries approximately half way between No. 1 and No. 80 trays. The overhead vapors pass under system pressure through a reflux and overhead product condenser to an accumulator. The system pressure is controlled from the base of the fractionation tower by a recording pressure controller regulating the flow of cooling water from this reflux and overhead product condenser. The condenser is mounted immediately over the accumulator with both mounted on steel supports on top of the roof of a steel reinforced concrete control and pump room. The reflux and overhead product pump is located directly under the accumulator thus about a 12-foot suction head is provided from the base of the accumulator. The flow of reflux and overhead product are both regulated by rate of flow controllers operating on the discharge of the pump. The reflux controller is manually set and the overhead product controller is automatically re-set by a level controller on the accumulator. The lever controller operates the full range of level in the accumulator and transmits the level in the accumulator to the overhead product flow controller where the level is also recorded on the chart. The level controller is also equipped with a low level alarm to protect the pump from emptying the accumulator and upon the level becoming too low a horn is sounded and a red light on the control panel goes out. The red light is identified by a tab to distinguish it from seven other red lights for similar purpose so that the source of the alarm is immediately identified.

The heat supply to the system is furnished from the 20-pound exhaust steam system introduced at full pressure to the heating element of the re-boiler. Temperature is regulated by a rate of flow controller and control valve on the steam condensate from the re-boiler re-set by a pneumatic-type recording temperature controller actuated from the eighteenth tray above the re-boiler. An alternate temperature control point is located in the re-boiler but temperature regulation from the eighteenth tray above the re-boiler works much better on this particular unit. In another plant where the rate of flow controller on the feed is manually re-set and the temperature of the feed is regulated, better results are obtained with the temperature control point in the re-boiler. At this other plant a short cable, pneumatic type, temperature controller was installed and the control point moved to the reboiler. At first this did not operate properly, but upon putting the feed to the system on manual re-set and installing a temperature controller on the feed, the system operates around the clock and through any abrupt atmospheric temperature change without adjustment of temperature control.

Again referring to the plant being described, the base product withdrawal is regulated by a level controller on the re-boiler and after passing the heat exchanger is pumped through a cooler and is metered enroute to storage. The



General View of Hooker Plant Looking West. Propane Storage is in foreground, power house in background, pipe line company's booster station in far background.

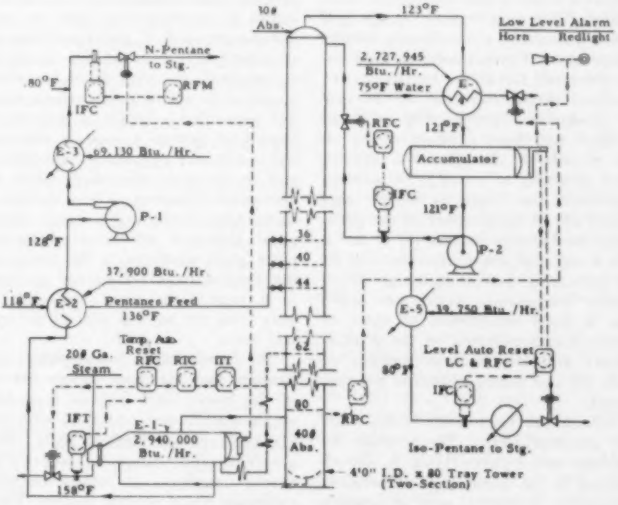
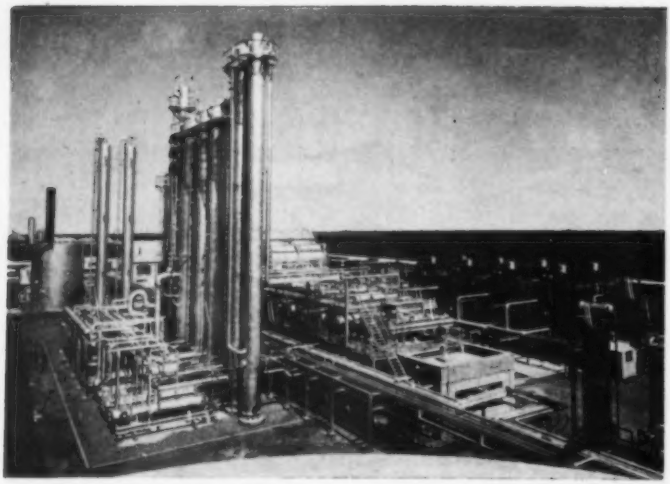


Figure 3. Fractionation of Pentanes.



General View of Panoma's Hooker Plant Showing Fractionators in foreground, water tank and power house in background and cooling tower to the right.

level control valve is on the downstream side of the meter flange.

The pneumatic-type temperature regulator used on this system has a 40-foot temperature cable reaching from the location of the instrument at ground level to the control point at the eighteenth tray above the reboiler. An indicating potentiometer connection is in the reboiler. In operation it is found that the readings on the potentiometer do not follow the recording of the pneumatic temperature controller by a fixed temperature increment upon atmospheric temperature changes. It is therefore obvious that the temperature cable of the temperature controller is not sufficiently compensated for temperature change and is not registering a consistently correct temperature. Furthermore, as these inconsistencies between temperature readings occurs the ratio of the rate of production between the overhead product and base product varies on the records of the meters metering these products to storage. Operating experience has taught us that we must adjust the set temperature of the pneumatic temperature controller to maintain a constant temperature reading on the indicating potentiometer as atmospheric temperature varies and when this is done consistency of rates of production is reflected on the product meters and specification purities of both iso and normal pentane are produced.

All control instruments in this plant are pneumatic type. Temperature recording and controlling is accomplished by an indicating temperature transmitter located as near as possible to the control point with the recording controller located on the control panel in the control room. Measurement recording and recording controlling is accomplished by an indicating flow transmitter near the orifice flange with the recorder or controller on the control panel. All instruments common to a unit are grouped on the control panel so the entire operation of the unit may be conveniently observed. All control instruments are equipped with manual control dials so the instruments may be serviced with the minimum of interruption and without pinching block valves.

It was recognized, at the time of selection of instruments, that for temperature controlling more accuracy would be accomplished and one less instrument used, if electronic-type instruments were selected. Electronic instruments do not have the underwriters approval of safety in hazardous areas and we wished to locate the potentially hazardous process pumps in the control room for operating convenience and to minimize operating labor requirement. However, a few electronic instruments including a large multipoint indicator are located behind plate glass windows in the center of the control panel. They are enclosed in a vapor-tight room accessible to only from the outside wall of the control room.

The fractionation system pumps and loading and blending pumps are all of the heavy duty process type with single glands and equipped with single seal-type mechanical seals. They are 3500 rpm direct connected by spacer couplings to totally enclosed explosion-proof electric motors. These units have given excellent service. The seals on the pumps have never had what could be called as much as a minor failure. Aside from one of the pumps which takes suction directly off the base of one of the fractionation towers, which had two very minor leaks during the first six months operation as a result of excessive scale and dirt entering the pump, all pumps operated two and one-half years before it was necessary to go into several of the pumps and resurface the bronze ring portion of the seal. No liquid or vapor leaks can be seen and it is doubtful that a flame test would show any leaks.

At the time this plant was designed it was found that the most economical type plant to obtain the recovery of products desired, with minimum fuel, required the use of process steam in the still. Further studies pointed the way to condensing type turbo-electric generators for electric power in which the steam generators for mechanical drive turbines and for two heating services could be operated as one central steam plant at one operating station. All pumps in the plant are centrifugal type and, except for four large horsepower services powered by mechanical drive turbines, with the exhaust used for heating the re-boilers of the fractionators, they are powered by electric motors. Thus, through the careful study and selection of the type plant, equipment, and instrumentation, the plant is practically maintenance free and operates in pushbutton fashion requiring only three shift operators to produce about 3200 barrels daily of an aggregate of six separate products including ethyl and house-brand gasoline made from the hexane plus product.

In conclusion, the foregoing substance may briefly be summarized as follows:

1) In multiple fractionation of a product of the character represented, intermediate separation followed by binary separation may be accomplished with less equipment and at an appreciable saving of energy than by consecutively fractionating the products from the charge stock in the order of volatility;

2) The greatest efficiency and maximum capacity of a fractionation system can be attained only through ample and good instrumentation properly applied; and

3) Maintenance may be held to a very low figure through the proper selection of equipment, the selection of low value product stream condensing and cooling temperatures in water cooling and condensing services and, though not previously mentioned, constant and careful conditioning of cooling water.

Extractive Crystallization—
A New Separation Process

Part II. Thermodynamic Considerations

KENNETH A. KOBE and WILLIAM G. DOMASK
Department of Chemical Engineering, The University of Texas, Austin

IN THE THEORETICAL discussion (Part I) of urea adduct formation, there was presented the physical concept of urea molecules becoming oriented in such manner as to form a canal into which straight-chain organic reactant molecules just fit. This concept is supported by data obtained from studies of crystal structure and adduct composition.

The material considered in Part II is concerned primarily with the thermodynamics involved in adduct formation, but it includes consideration of certain physical properties and a brief discussion of thiourea adducts.

AS FURTHER evidence of the workability of the spatial concept of urea adducts, Schlenk[31] presents a comparison of experimental and calculated densities of some of the adducts. The elementary cell of tetragonal urea (pure urea—not the adduct) contains two molecules of urea with $a = 5.73$ Angstrom units and length $c = 4.77$ Angstrom units. Thus, the volume can be calculated:

$$V = (5.73)^2 (4.77) = 156.5 \text{ (Angstrom units)}^3$$

For hexagonal urea, $a = 4.75$ Angstrom units, $c = 11.1$ Angstrom units and there are six molecules in the unit cell. The volume may be calculated using the equation for a hexagonal prism, as expanded from the area of six equilateral triangles, where a is the base distance and c is the altitude:

$$V = (a/2)\ (a/2)\ (\sqrt{3})\ (c)\ (6).$$

Thus,

$$V = (4.75/2)^2 (\sqrt{3})\ (11.1)\ (6) = 650.66 \text{ (Angstrom units)}^3$$

For two molecules of urea this becomes $(650.66)/(3) = 217$ (Angstrom units)^3. From this it is seen that the weight of one cubic centimeter of hexagonal urea must be $(156.5)/(217)$ times as great as tetragonal urea.

The density of tetragonal urea, as calculated, agrees with the literature value of $d_4^{20} = 1.323$. In the case of hexagonal urea, the calculated value is

$$(1.323)\ [(156.5)/(217)] = 0.956.$$

In addition to this weight of hexagonal urea, one cubic centimeter of adduct also contains the reacted amount of organic component. This latter amount may be obtained by analysis. In actual experiments, pycnometers were used in obtaining densities. A pycnometer was about half filled with an adduct, the weight of which was determined, and the remaining volume was determined by adding an "inert" liquid. The filling liquid was usually *n*-heptane. This, of course, is able to form an adduct by equilibrium exchange; however, as established in control experiments, exchange of *n*-heptane with heavier reactants occurs extremely slowly. Non-adduct formers, like isooctane and benzene, cause equilibrium decomposition, and in general are not suitable.

TABLE 2
Densities of Urea Adducts

Organic Component in Adduct	Density (d_4^{20}) Calc.	Exp.
n-Dodecane	1.205	1.203
Cetane	1.205	1.200
4,4'-Dichlorodityl ether	1.310	1.307
Lauric acid	1.248	1.242

A few of the results are shown in Table 2.

It is seen that the results are in favorable agreement. This can be taken as further evidence of the exactness of both the developed space concept of the adducts and of the analytical results.

Heat of Formation of Adducts

As pointed out by Schlenk,[31] it is to be anticipated that the heat of formation of adducts should decrease with the size of the reactant molecule, because of the corresponding percentage increase in unoccupied canal volume (there is a calculated distance of 2.4 Angstrom units between reactant molecules). Heats of adduct formation are reported by several workers. Zimmerschied et al.[38] point out that the heats of reaction are closely proportional to the length of the carbon chain, and a plot of data for the several classes of compounds results in a family of approximately parallel lines. Some of the data are given in Table 3.

TABLE 3
Heats of Adduct Formation

COMPOUND		$-\Delta H$, Kg. Cal. Per	
Name	Carbons	Mole	$-CH_2-$
n-Heptane	7	7.6	1.5
n-Hexadecane	16	22.8	1.6
Octadecene-1	18	33.6	1.6
n-Dodecyl mercaptan	12	14.0	1.3
Dodecanol-1	12	11.7	1.1
Methyl stearate	19	32.2	1.2

Zimmerschied et al. compare the observed value of 1.6 kg. cal. for each carbon atom in the alkanes with a variety of physical transformations. This observed value is far greater than heats of crystal transitions in hydrocarbons. It is more than twice the equivalent heat of fusion and even half again as great as the heat of vaporization per carbon atom. It is less than the heat of adsorption values available for hydrocarbons on solid surfaces, although it appears to resemble adsorption more closely than any other familiar process. However, evidence is presented to show that it is not a classical adsorption process. To prove that adduct formation is not an adsorption process, Schlenk reasons that if the reactant were adsorbed onto the urea, the vapor pressure of the reactant, after pumping some of it off, would become increasingly smaller as less reactant remained adsorbed. On the contrary, if the adduct were a chemical compound, the vapor pressure would be a constant value as long as any adduct existed. Experiments showed the latter to be the case—the vapor pressure remained constant. Thus, the heat evolved in adduct for-

mation may be attributed to chemical transformation rather than physical adsorption.

Lattice Energy of Adduct Formation

The formation of urea adducts is an exothermic process. The lattice energy is here considered separately, because it is being considered in the light of the individual types of energies which combine to give the net heat of reaction, which can be measured calorimetrically.

Schlenk[31] considers the measured heat of reaction in adduct formation as resulting from three distinct steps:

1) The overcoming of molecular adhesion of the reactant molecules in the liquid state to form isolated single molecules.

2) The addition or combination of the reactant molecules and the urea molecules.

3) The transformation of urea from a tetragonal lattice to a hexagonal lattice.

In Step 1, the energy involved is the same as in a vaporization process, inasmuch as it involves transformation of the material from a liquid state to one of single molecules. Values for Steps 2 and 3 cannot be measured directly but can be calculated by an indirect method. Inasmuch as the urea is transformed from hexagonal form to tetragonal form when the adduct is decomposed by extraction or vaporization, Schlenk reasons that the tetragonal form is favored energetically. He thus concludes that the transformation from tetragonal to hexagonal form is accompanied by the consumption of heat.

Three Steps

In order to illustrate how these three steps are combined from the standpoint of the energies involved, let $Q_1 = L =$ the latent heat of vaporization of the liquid organic reactant. Since vaporization is endothermic, this value is used as $-L$. Let Q_2 represent the heat of addition for Step 2, and $-Q_3$, the heat of transformation for Step 3; the heat of reaction as determined calorimetrically may be represented by Q'. When these values are combined, there results the following equation:

$$Q_2 - Q_3 - L = Q'. \qquad (3)$$

As already pointed out, the values of Q_2 and Q_3 for a particular adduct cannot be obtained directly. However, as will now be shown, they can be evaluated if dealt with in terms of Q_2 and Q_3 per Angstrom unit of canal length. In order to calculate Q_2 and Q_3, *n*-octane and cetane may be used in an example. The occupied and free canal lengths are 10.4 Angstrom units and 2.4 Angstrom units, respectively, for one molecule of octane, and 20.5 Angstrom units and 2.4 Angstrom units, respectively, for one molecule of cetane. Now, considering values of Q_2 and Q_3 per Angstrom unit of canal length for one molecule, and substituting the above data into Equation (3), there result the following simultaneous equations:

$$10.4Q_2 - (10.4 + 2.4)Q_3 - L_{(octane)} = Q'_{(octane)} \qquad (4)$$

$$20.5Q_2 - (20.5 + 2.4)Q_3 - L_{(cetane)} = Q'_{(cetane)} \qquad (5)$$

The heats of vaporization, L, for octane and cetane are 9525 and 18,770 cal. per mole, respectively; the measured heats of reaction, Q', are 7160 and 14,900 cal. per mole, respectively. Substituting into Equations (4) and (5), there are obtained:

$Q_2 = 2185$ cal./Angstrom unit;

$Q_3 = 488$ cal./Angstrom unit.

For octane, the molar heat of addition (Step 2) becomes (10.4) (2185) = 22,750 cal. If the CH_2 and CH_3 groups are considered as equivalent, the value per CH_2 group for octane becomes (22,750)/(8) = 2840 cal. The value of transformation (Step 3) per mole of urea (there are 1.87 Angstroms of canal length per molecule of urea) becomes (1.87) (488) = 914 cal. per mole of urea.

The energy of transformation (Step 3) per mole of urea and the heat of addition (Step 2) per CH_2 apparently should be constant values; upon inspection of the procedure, however, it is seen that an inherent error is introduced in this difference calculation in that through the use of the value 2.4 Angstrom units, a truly exact basis of comparison has not been used. It can be seen that the value, 2.4, is of relatively more importance for short than for long molecules. The differences between Q_2 and Q_3, respectively, become smaller, and the values become more nearly constant as the size of the reactant molecules increases. Although the procedure described here is inexact, a method is provided for calculating effects introduced by other groups, such as carboxyl and hydroxyl groups.

The value of the method just described, along with the use of values calculated by this method, may be demonstrated by a calculation of the molar heat of addition (Step 2) of a carboxyl (CO) group. For methyl ethyl ketone, and the adduct which it forms with urea, the following data have been compiled:

Length of molecule = 5.3 Angstrom units.
Length of CO group = 1.25 Angstrom units.
Length of paraffin parts = 4.05 Angstrom units.
Canal length belonging to adduct = 5.3 + 2.4 = 7.7 Angstrom units.
Heat of vaporization = 8510 cal./mole.
Heat of formation Q' = 4285 cal./mole of ketone.
x = the increment of molar heat of addition of CO group.

Using average values of $Q_2 = 2150$ cal./Angstrom unit for addition, and $Q_3 = 520$ cal./Angstrom unit for lattice transformation, the known data may be substituted into Equation (3) to give the following:

$$(4.05)\ (2150) + x - (7.7)\ (520) - 8510 = 4285. \qquad (6)$$

From this, $x = 8095$. Thus, the molar heat of addition (Step 2) for the CO group is 8095 cal. This demonstrates the use of values calculated for various groups in obtaining additional data.

An additional matter of interest concerning lattice energy is that there appears to be an upper limit of reactant size beyond which adduct formation will not take place. Schlenk reports that octaeicosane, $C_{28}H_{58}$, forms an adduct without difficulty; however, $C_{55}H_{112}$ could not be made to form an urea adduct. These long chain compounds have high lattice energies, as is evidenced by their high melting points and high heats of fusion. The heat of fusion of the homologs is not a function proportional to the chain length, but it progressively increases in excess of direct proportionality. Schlenk points out that in the equilibrium reaction for adduct formation, the reactant also exhibits its tendency to form its own pure crystals, as in the case of a high paraffin wax. Thus, it appears possible that a threshold exists beyond which crystallization of the reactant is favored energetically over the formation of an adduct. However, Fetterly[11] points out that packing diagrams do not agree with this hypothesis. In general, the stability of urea adducts increases with the chain length of the reactant, and Fetterly maintains that this trend in potential stability should continue. He indicates that the apparent lack of reactivity here must be due to a lower rate of reaction rather than a decreasing equilibrium. This is in agreement with an observed increase in reactivity when the reaction and urea saturation temperature is raised to 60° C. However, the upper chain length limit is very real, for as the temperature is raised to increase the solubility of the wax in the solvents, the stability of the urea lattice decreases, and it finally reaches its melting point at 132.7° C.

Adducts of Non-Cetane Type Structure

Most of the adducts studied were found to be of the same type as the cetane-urea complex. This was evi-

denced by the similarity of the X-ray powder diagrams. However, a few cases were noted for which the crystals were definitely not of the cetane-urea type. There appears to be no way of predicting whether substituted compounds will be of the cetane type. 1,6-difluorohexane, 4,4'-dichlorodibutyl ether and 1,5-dibromopentane are all of the cetane type. 1,4-dichlorobutane and 1,6-dichlorohexane are of the same type but not the cetane type, and 1,6-dibromohexane is still a different type. It is noted that dibromopentane and dibromohexane are homologs, yet they possess two different non-cetane type lattice structures. Similarly, acetone and dioxane and some of the lower acids are non-cetane types. A conclusive explanation of these deviations has not been given; however, it is noted that they occur in the cases of relatively small molecules, and there is possibly a transition region above which the various types of compounds conform with the cetane type of adduct.

Dissociation of Adducts

It has been established that the adducts are definitely not pure adsorbates but are of a chemical nature, just as much so as $CuSO_4 \cdot 5H_2O$. In view of this, the adducts should obey classical laws in the same manner as other compounds. One of these laws is the Clausius-Clapeyron equation. The calculated heat of formation of the heptane-urea adduct is 14,370 cal. per mole. At 0°, 10° and 20° C., the vapor pressures of the heptane adducts are 3.3, 8.0 and 19 millimeters, respectively. Starting with the Clausius-Clapeyron equation, the following relation may be derived for the heat of dissociation, λ, of adducts.

$$\frac{d \ln P}{d(1/T)} = -\frac{\lambda}{R}$$

$$\lambda = \frac{(2.3)\ (\log P_2 - \log P_1)\ (T_2)\ (T_1)}{(T_2 - T_1)} \quad (7)$$

The calculated heats of dissociation, λ, for the two ten degree intervals are 13,600 and 15,100 cal. per mole of heptane. These values are in reasonable agreement with the previously obtained value of 14,370.

When a pure adduct is put into a solvent, an equilibrium is established among the components of the system. The same equilibrium can be expected when a reactant in a solvent is combined with pure urea. Schlenk[21] reports equilibrium studies for the system *n*-heptane in isooctane and excess urea:

$$\text{Heptane adduct} \rightleftarrows \text{urea} + \underset{\text{(isooctane)}}{\text{heptane}}$$

According to the equation, heptane could not be removed from a reaction mixture by adduct formation, even if excess urea were present. For such a system at 10° C., the heptane content of the remaining mixture was found to be 40 percent, at 5° C., 30 percent, and at —10° C., 20 percent.

The possible solvents which could be employed to dissociate adducts are a) those which dissolve only the organic component, b) those which dissolve only urea, and c) those which are solvents for both. As might be expected, the solvents of Type c bring about the strongest dissociation. Nevertheless, dissociation by such solvents, even with high dilution, is not always complete. For example, for decane-urea in methanol at 26° C., the following equilibrium resulted: 1 mole of adduct (1 mole decane and 8.1 moles urea) dissociated to the extent of 69 percent in 90 moles of methanol. Independently, 2.6 moles of decane and 13.5 moles of urea will dissolve in 90 moles of methanol.

An example of the action of a solvent of Type b is given by water. Inasmuch as water has very high solvent ability for urea, generally a moderate amount of water is sufficient for virtually complete adduct dissociation. In the case of a cetane adduct (1 mole cetane and 12 moles urea) dissolved in 72 moles of water at 31° C., the adduct dissociated to the exent of 97.5 percent.

In the case of solvents of Type a, for the organic component only, numerous examples were studied: urea-cetane toward benzene, carbon tetrachloride and isooctane; cetyl alcohol-urea toward benzene and carbon tetrachloride; lauric acid-urea toward benzene, isooctane, cyclohexane, carbon tetrachloride and chloroform. In all cases, the solvent took up the organic component to a content of 0.1 percent or less. Thus, equilibrium here definitely favors the undissociated adduct.

To a large degree, the dissociation constant is dependent upon the molecular size of the bound organic component. The tendency to dissociate decreases as the molecular size increases. This is in agreement with facts established concerning lattice energy. The magnitude of the influence may be shown by the following example:[21] 0.01 mole of heptane adduct dissociated virtually completely in one mole of benzene, but 0.01 mole of cetane adduct dissociated only to the extent of 3.3 percent.

Dissociation by Heating

The most practical means of dissociation of adducts for recovery of the reactants will generally be liquid phase dissociation, as already discussed. When a hydrocarbon-urea adduct is dissociated by an excess of water, two immiscible layers result; the urea is dissolved in the water, and the hydrocarbon layer may be readily drawn off the top. However, the adducts may also be dissociated by heating. Adducts containing more volatile reactants, such as *n*-hexane and *n*-heptane, are relatively unstable at room temperature. As the temperature is raised, the tendency for dissociation of the adduct increases, because the lattice energy of the urea complex steadily decreases until the melting point of urea is reached at 132.7° C.

Free Energy of Adduct Formation

In order to extend knowledge of adduct formation to various conditions, it is desirable to consider the free energy changes involved in reaction or decomposition. Redlich et al.[26] have reported studies for the decomposition of numerous adducts according to the following reaction:

$$\text{Complex (s)} \rightleftarrows \text{Reactant} + m\ \text{Urea (s)} \quad (9)$$

According to this definition, the value of the equilibrium constant, K, is equal to the mole fraction of the reactant in a perfect solution which is in equilibrium with the complex and solid urea. The reciprocal of K is a measure of the stability of the complex.

The standard free energy change, $\Delta G°$, for the reaction may be evaluated by determining the value of the equilibrium constant. The relationship between $\Delta G°$ and K is given by the following equation:

$$\frac{-\Delta G°}{T} = R \ln K. \quad (10)$$

For determining or using the equilibrium constant under actual conditions, the activity, a_r, of the reactant and the activity, a_u, of urea must be known in order to satisfy the following equation:

$$K = a_r a_u^m \quad (11)$$

Activity coefficients are available for mixtures of *n*-paraffins and other hydrocarbons of moderate molecular weight. Data are also available for urea in aqueous solutions over limited ranges. In the determination of K, only hydrocarbon mixtures and aqueous solutions were used.

Redlich et al. describe several methods for obtaining equilibrium constants, K, based on direct analysis of the equilibrium mixtures.

1) Aqueous reaction, where equilibrium is established between the pure reactant, aqueous urea solution and the complex.

2) Non-aqueous reaction, where equilibrium is established between a solution of the reactant in a non-react-

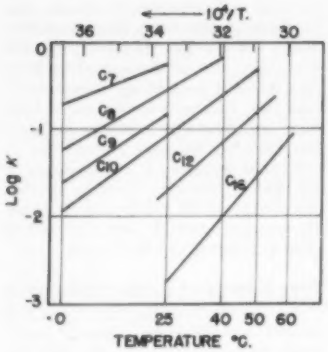


Figure 11 (above). Dependence of Equilibrium Constants of n-Paraffins on Temperature.

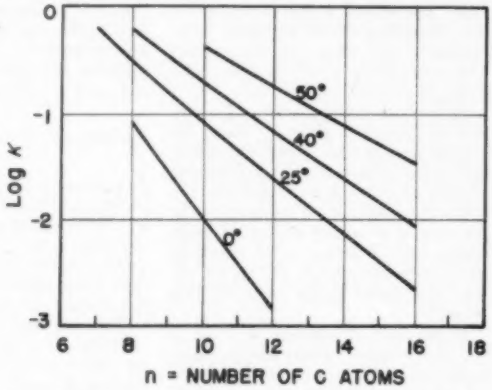


Figure 12 (right). Influence of Chain Length of n-Paraffins on Equilibrium Constants.

ing hydrocarbon and powdered urea.

3) Dew point method, which is based on the relation

$$K = p/p^{\circ} \qquad (12)$$

where p° is the vapor pressure of the pure reactant, and p is the decomposition pressure, that is the partial pressure exerted upon partial decomposition of the complex such that complex, urea and reactant are in equilibrium. The data are obtained by using a dew point apparatus described by Redlich et al.[26]

After the equilibrium constants have been determined for a number of systems under various conditions, the results can be presented in graphical form. In Figure 11 is shown the relationship between K and temperature. Figure 12 presents K as a function of the number of carbon atoms in the chain of the organic reactant. It can be seen from these curves that the value of the equilibrium constant for dissociation increases as the temperature increases. On the other hand, as shown in Figure 12, the value of K decreases as the chain length increases, indicating the greater stability of complexes containing larger organic molecules. The increase in stability with chain length is much more rapid at lower than at higher temperatures, as can be seen from the isotherms of Figure 12. Both of these sets of curves apply to *n*-paraffins.

Similar relationships can be prepared for systems other than the *n*-paraffins. Sufficient data are also available to obtain a relationship between K and the molal ratio m. A plot of log K as a function of m gives essentially a straight line which can be represented by

$$\log K = 2.20 - 0.403m \text{ (at 25° C.)} \qquad (13)$$

For interpolation, extrapolation and estimation of K for other substances, a diagram of K/K_p as a function of n, as shown in Figure 13, is useful. In this diagram, n is the number of carbon atoms, K is the equilibrium constant of the members of a homologous series, and K_p is that of the corresponding *n*-paraffins. The values for K/K_p approach unity with increasing n, as would be expected. Redlich et al.[25] point out that the temperature dependence of K/K_p is only slightly greater than the experimental errors.

Relationships have already been given between log K and $(1/T)$, and between log K and the number of carbon atoms, n. It is also desirable to have a relationship between the heat of adduct formation, ΔH, and n. One method of obtaining this relationship is by calorimetric determinations. In another method, the van't Hoff relation may be used. This relation is given by the following equation:

$$R\left[\frac{\partial \ln K}{\partial (1/T)}\right]_p = -\Delta H^{\circ} \qquad (14)$$

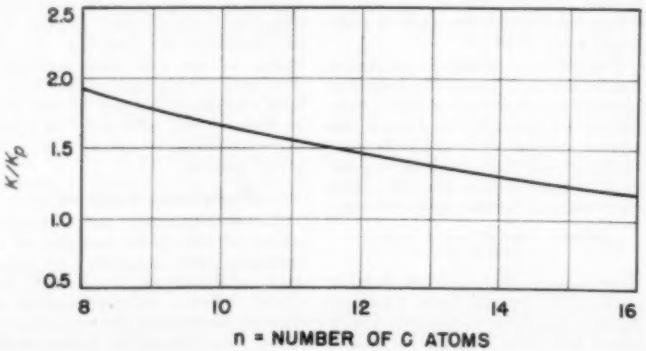
A plot of the relationship between ΔH in k cal./mole and n for *n*-paraffins is given in Figure 14. One might reason that a straight line should be expected if the "canal" concept is valid. However, Schlenk's concept of spacing in the canals is useful in providing an explanation for the curvature. If 2.4 Angstrom units of "unoccupied" canal length exists between successive reactant molecules in the canal, the heat of formation per carbon atom will not be a constant value, and as a consequence, there will be slight curvature in the line as shown.

With the known relationship between ΔH and n, and since compositions of the adducts are known, it is possible to obtain a relationship between ΔH and the molal ratio, m. As shown by Redlich et al.,[26] a plot of ΔH as a function of m gives essentially a straight line, which can be represented by the equation:

$$\Delta H = -6.5 + 2.37m \qquad (15)$$

The equations relating K, ΔH and m are not rigid, but they may prove useful in obtaining information for making predictions of maximum yield and other basic data for applications in which a single substance is precipitated. Figures 15 and 16 illustrate a few details. The equilibrium between a *n*-paraffin in a hydrocarbon mixture

Figure 13 (below). Dependence of K/K_p on Number of C Atoms.



and an aqueous urea solution is described by Figure 15. The rapid increase of the mole fraction x of paraffin with decreasing urea concentration emphasizes the importance of maintaining urea saturation. The stability field of a n-paraffin complex is described by Figure 16. The top line is a saturation curve which indicates the solubility of urea in water. A complex is stable in contact with an aqueous solution if the urea concentration exceeds a certain value, "the decomposition concentration." The stability field is enclosed by the saturation line and the decomposition line. These two curves intersect at the decomposition temperature, for which $K = 1$. Above this temperature the adduct does not exist under any conditions. For example, the urea adduct containing C_{10} in an aqueous system must have a urea concentration in solution above the solid line for C_{10} in Figure 16. Of course, if the free urea present is greater than the concentration indicated by the dotted saturation curve, then urea will be present in the solid phase also, but this is of no significance, since the maximum urea concentration in solution is given by the dotted line. If the urea concentration at a given temperature is below that indicated by the solid line, then sufficient decomposition of the adduct will occur to bring the urea concentration onto the solid line; decomposition of the adduct will then cease, because the adduct is again in a stable system. the maximum temperature at which the C_{10} adduct can exist is about 65° C. Above this temperature, complete decomposition will occur.

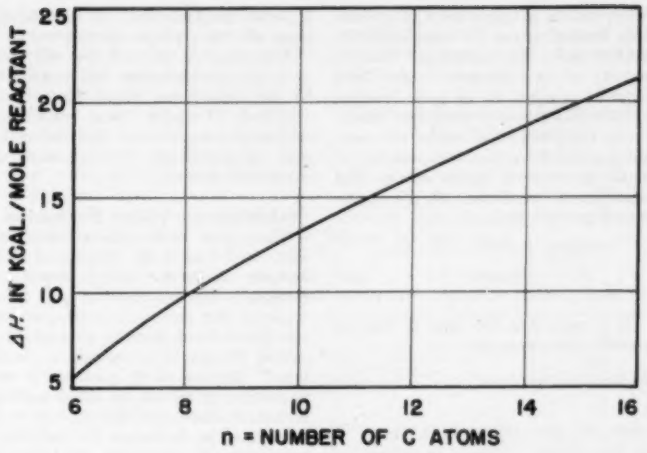


Figure 14. Heat of Formation of n-Paraffins.

Thermodynamics of Mixtures of Reacting Substances

In practical applications of urea adduct formation, the organic reactants will in many cases consist of mixtures. In this connection, Redlich et al.[26] have considered the practical situation wherein mixtures of reacting substances are involved. In the case of mixtures, two different cases may be taken into consideration: a) Each complex represents a separate solid phase; that is, only one type of reactant molecule will be found in any given canal or crystal; and b) A single solid phase exists such that there is a single solid solution of all reacting substances in urea. According to the results of crystal structure analysis, Case b rather than Case a is to be expected.

The two cases can be distinguished by an examination of a mixture of two n-paraffins and another hydrocarbon (n-heptane, n-octane and decalin at 0° C.) and solid urea. In Case a, the mole fractions x_7 and x_8 in the mother liquor cannot fall below the values K_7 and K_8 of the respective equilibrium constants. This is shown by the following consideration:

$$\text{complex (s)} \rightleftarrows C_7 + m_7 \text{ urea (s)} \qquad (16)$$

$$K_7 = \frac{(a_7)\ (a_u)^{m_7}}{(a_{c_8})} = a_7 = x_7 \qquad (17)$$

where m_7 is the number of moles of urea per mole of heptane, a refers to the respective activities, and a_{c_8} refers to the activity of the complex. Here the activities of the solid substances are taken as unity, and the activity of C_7 is approximately its mole fraction. Similarly, $K_8 = x_8$. So if Case (a) were true,

$$x_7/K_7 = x_8/K_8 = 1 \qquad (18)$$

Actually, Redlich et al. have found that they approach much lower values which satisfy the relation

$$x_7/K_7 + x_8/K_8 = 1 \qquad (19)$$

This is further evidence that the

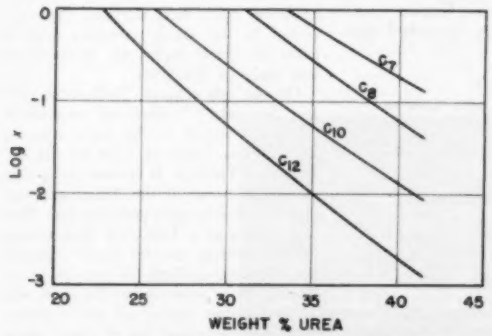


Figure 15. Influence of Urea Concentration on the Equilibrium Mol. Fraction x of n-Paraffins (Aqueous Urea Solutions at 0° C.)

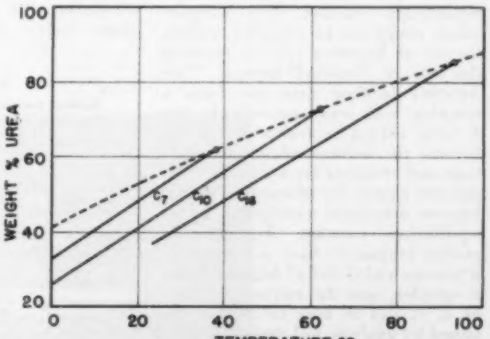


Figure 16. Stability Fields of n-Paraffins.

precipitate is a single solid. The complex formation can be completely described under the assumption that the activity of any reactant in the solid solution is equal to its mole fraction γ_i calculated on a urea-free basis. (γ_i = the number of moles of reactant i divided by the total number of moles of reactants in the solid.) The equilibrium constant may be represented as follows:

$$\text{complex}_i\ (s) \rightleftarrows C_i + m_i\ \text{urea}$$

$$K_i = (a_i)\,(a_u)^{m_i}/(\gamma_i). \qquad (20)$$

It is seen that the ratio of the two equilibrium constants

$$K_1/K_2 = [(a_1\gamma_2)/(a_2\gamma_1)]\,a_u^{(m_1-m_2)} \qquad (21)$$

plays the same role in urea separation as the relative volatility in distillation if $m_1 = m_2$ or if solid urea is present. This ratio is useful for a direct determination of equilibrium constants.

Example By Schlenk

From a mixture, even a substance whose complex is unstable by itself ($K_i > 1$) can be precipitated. An example of this was reported by Schlenk[31] when he formed an adduct from a mixture of 3-methyl heptane and a *n*-paraffin. Conversely, a value of $K_i > 1$ can be determined by investigation of a mixture with the ratio equation. From observations made by Redlich et al. on a mixture of *n*-heptane and 2-methyl nonane, it was found that the equilibrium constant of the latter lies between 3.1 and 4.4 at 25° C. In a similar way, the upper limit 3.2 at 25° C. was obtained for methyl tridecane. When these values are compared with those of the corresponding *n*-paraffins, it is found that appreciable contamination of a *n*-paraffin below C_{16} with 2-methyl paraffins is to be expected, but other isomers are not likely to be present.

An example of a calculation of the equilibrium constant of a complex which could not be obtained without the use of Equation (21) is given in the case of 3-methyl heptane. Pure 3-methyl heptane does not form a complex with urea; accordingly, the K value cannot be evaluated directly, because the corresponding concentrations and activities for the equilibrium mixture cannot be measured. Normal heptane does form a complex, and its equilibrium constant, K_7, may be readily evaluated. Also, a mixture of *n*-heptane and 3-methyl heptane forms a complex, and the respective values of a, γ, and m may be readily obtained by analysis and through knowledge of the activities. Thus, by using Equation (21), the K value for 3-methyl heptane may be calculated, since all other values are known.

The relations derived for mixtures of reacting substances are restricted by the conditions which have been specified. However, these conditions will satisfy many cases, and the methods employed can be extended to other complexes.

Inhibitors to Adduct Formation

Many pure hydrocarbons form adducts with urea in the absence of such solvents as methyl ethyl ketone or methanol. Zimmerschied et al.[38] have reported that petroleum fractions usually fail to form adducts, even slowly, in the absence of a solvent or "activator," because of the presence in the petroleum of substances which inhibit adduct formation. This failure can sometimes be overcome by "seeding" with a small amount of freshly prepared adduct. In order to study the nature of these substances, an inhibitor to adduct formation was concentrated from 720 grams of a petroleum fraction. Concentrate in the amount of 1.7 grams containing 6.1 percent sulfur was obtained. The amount and properties of the inhibitor suggested that it consisted of nonhydrocarbon impurities which normally occur in traces in petroleum. This would include sulfur compounds, peroxides, and other substances; they appear to be removed by adsorption on urea adducts. When added in small amounts to *n*-alkanes, the inhibitor prevented formation of urea adducts. For example, *n*-hexadecane containing 0.25 percent added inhibitor formed no adduct until 0.4 percent methanol was also added. However, these inhibitors apparently present no problem in adduct formation when a solvent is used along with the urea and reactant.

Theory of Thiourea Adduct Formation

Thiourea forms complexes with many compounds which do not form complexes with urea. Known complexes include highly branched paraffins, some cycloparaffins, some slightly unsaturated members of the foregoing types, and highly chlorinated or brominated compounds.

TABLE 4
Adduct Formation with Thiourea

Adduct Formers	Non-Adduct Formers
Cyclopentane	n-Pentane
Menthane	n-Hexane
Decahydronaphthalene	Tetramethyl ethane
Isopropyl iodide	Benzene
Tertiary-butyl chloride	Toluene
Tertiary-butyl bromide	Naphthalene
Tertiary-butyl iodide	Methyl iodide
Cyclohexyl chloride	n-Propyl iodide
Tetrachloroethane	Methanol
Carbon tetrachloride	n-Butanol
Methyl cyclohexane	Nitrobenzene
Acetophenone	Amyl acetate
Cyclohexanone	Tertiary-butanol
Borneol	n-Butyl iodide
Camphor	Allyl alcohol

TABLE 5
Composition of Thiourea Complexes
(Thiourea/Reactant)

	Molal Ratio	Weight Ratio
2,2-Dimethylbutane	2.6	2.3
2,3-Dimethylbutane	2.4	2.1
2,2,3-Trimethylbutane	2.9	2.2
2,2,4-Trimethylpentane	3.3	2.2
2,2,4,4-Tetramethylpentane	4.0	2.6
Cyclopentane	2.4	2.6
Methylcyclopentane	2.9	2.6
Methylcyclohexane	2.9	2.3
Isopropylcyclohexane	4.1	2.5
Carbon tetrachloride	3.9	1.9
Cyclopentene	2.2	2.2
Cyclohexanol	3.0	2.3
1,2-Dicyclohexylethane	6.0	2.5
n-Undecylcyclohexane	8.9	2.8
2,6,9,12,15-Pentamethylheptadecane	11.0	2.7

Angla[1] made an extensive study of substances which react to form adducts with thiourea. Some of his results are listed in Table 4. It is apparent that a generalization can not be made so well for thiourea as was done for urea. However, in general, thiourea does not form adducts with compounds which form adducts with urea.

Composition of Thiourea Adducts

The principal sources of data for thiourea adducts are those reported by Angla,[1,2,3] by Redlich et al.[27] and by Schlenk.[31a,34] These data are not in exact agreement; the differences can probably be attributed to different concepts of structure.

The methods of analysis of thiourea adducts were essentially the same as those discussed for urea. Angla reports that the adducts consist of three moles of thiourea to one mole of reactant, $M \cdot 3CS(NH_2)_2$. An exception to this was obtained in the ternary system of camphor, thiourea and methanol. In this case Angla obtained ratios of four and five in instances where the methanol was not absolute; however, upon long stirring, these reverted to the stable complex with a ratio of three moles of thiourea to one mole of reactant.

On the other hand, Redlich et al.[27] and Schlenk[31a,34] obtained non-whole numbered ratios in the same manner as for urea. Some of their results are shown in Table 5. It is seen from this table that some of the ratios are reasonably closely grouped together. This probably was a factor in designating $M \cdot 3CS(NH_2)_2$ as the ideal formula for thiourea adducts as was done by Angla. It is seen from Table 4 and Table 5 that many of the reactant molecules reported are of short chain length or are ring-type compounds with short equivalent lengths. The last

five compounds listed in Table 5 are from data for 108 compounds reported by Schlenk.[31a] It is seen that some of the long compounds also form adducts with urea, and in these cases higher mole ratios of thiourea to reactant are realized, very much in the same manner as was reported for urea adducts.

Structure of Thiourea Adducts

Angla[1] has pointed out the difficulty involved in attempting to explain the structure of the thiourea complexes. The classical theory of valence does not lead to a solution of the problem of bonding and structure, so he makes use of the electron theory of valence in explaining the formation of some of the adducts. His interpretations are made without the aid of X-ray data, and they involve hydrogen bonding and coordination between the atom of sulfur in thiourea and an atom in the reactant molecule.

X-ray studies indicate that the structure of thiourea adducts is of the same general type as that of urea adducts. Hendricks[14] found that pure thiourea crystals have a rhombic structure. Smith[28] reports that incomplete X-ray studies of the thiourea complexes indicate that the unit cell is rhombohedral. A more recent article by Schlenk[31a] confirms the rhombohedral structure. Schlenk[24, 31a] states that the canal concept must hold for thiourea adducts just as it did for urea adducts, because some long molecules form adducts just as easily as the more compact short molecules without altering the basic lattice. As was the case with urea adducts, the amount of thiourea per mole of reactant is approximately proportional to the length of the reactant molecule.

The arrangement of thiourea molecules in the thiourea adduct is comparable to the arrangement shown in Figure 5 (Part I) for the hexagonal system of the urea complex. There are six molecules of thiourea in the unit cell; however, the arrangement of these molecules is not so simple as was the case for urea. The larger size of the sulfur atom in thiourea, compared with the oxygen in urea, results in a canal with a larger cross section. The distance between two molecules lying one above another is 4.2 Angstrom units, and the edge length of the unit cell is 5.37 Angstrom units; these values compare with 3.7 and 4.8, respectively, for urea adducts. The canal length of the unit cell for thiourea is 12.5 Angstrom units compared with 11.1 Angstrom units for urea adducts.

When the data for homologous series of thiourea adducts are plotted as shown in Figure 2 (Part I) for urea adducts, an anomaly is observed in that constant mole ratios of 6 to 1 and 9 to 1 are obtained for a few members of the series. This results in a limited step-wise arrangement of the data points instead of a straight line as shown in Figure 2. For example, dicyclohexylmethane, 1,2-dicyclohexylethane and 1,3-dicyclohexylpropane all have a thiourea to reactant ratio of 6 to 1. This is explained as resulting from compression of the paraffinic portion of the reactant molecule within the canal. This is possible because the slender portion of the dumbbell-shaped molecule can be deformed by compression and still fit into the relatively large cross section of the thiourea canal. Such "space economy" through compression is also recognized for other reactants which contain unbranched paraffinic sections. This situation is not encountered to any appreciable degree in the case of urea adducts because of the relatively small diameter of the urea adduct canal.

With regard to the stability of the adducts, it may be stated generally that for branched paraffins, the more side chains there are, the higher is the affinity for adduct formation. However, large side groups, such as ethyl and isopropyl groups, tend to hinder adduct formation. In the case of cyclic reactants, saturated compounds generally yield more stable adducts than unsaturated compounds.

Thermodynamics of Thiourea Adduct Formation

The heats of formation of thiourea adducts are much lower than those obtained for urea. Some of the calorimetric data obtained by Angla[1] are shown in Table 6.

TABLE 6
Heats of Formation of Thiourea Adducts

Reactant	k-cal./mole
Carbon tetrachloride	3.3
Hexachlorethane	3.1
Cyclohexane	3.6
Cyclohexene	3.1
Cyclohexanone	2.6
Camphor	4.9

In agreement with the low heats of formation is the fact that the thiourea adducts are much less stable than those of urea. They dissociate readily, even at low temperatures.

Extensive equilibrium data, as were obtained for urea adducts, could not be obtained for thiourea. Redlich et al.[27] utilized the limited activity data which existed for thiourea in calculating equilibrium constants. The low stability of the complexes is reflected in the equilibrium constants; even at 0° C. the values of K are greater than 0.05 for dissociation. This corresponds approximately to the urea complex for *n*-octane. No relation could be developed between free energy, the heat of formation and the molal ratio, as has been done for urea, and compared with urea complexes, free energy and heat of formation as well as molal ratio are low.

End of Part II. Part III will appear in an early issue.

NOTE

All "Literature Cited" was listed at the end of Part I.

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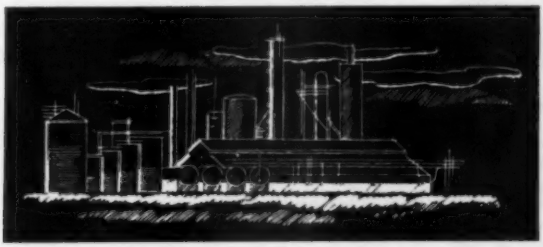


Oil's Heavy Capital Outlay Rates High Among All Industries

ROBERT E. SPANN, Eastern Editor

THE petroleum industry's rate of capital expenditures in the immediate future will be the largest of any industrial group as indicated by projected investments in new property, plant and equipment for which accelerated tax amortization has been requested.

This form of tax credit to stimulate private industry's ability to finance the unusually large industrial expansion program projected following the outbreak of the Korean war had been approved by Defense Production Administration for new production facilities with total proposed investment of $16.9 billion by the end of March. DPA estimates that of the projected defense building program that got underway in September of 1950, more than half was in place at the end of the first quarter and that by the end of 1952 approximately 63 percent of the dollar value of the over-all expansion program will be completed. By the end of next year it is expected to be 94 percent completed. (Table 1.)

Based on the outstanding requests for certificates of necessity for rapid tax write-offs for new facilities as of the end of February, the latest date for which detailed figures are available, all industrial groups had proposed new investments involving capital outlays of more than $9.8 billion, of which the largest was the petroleum industry's total proposed expenditures of $1,741,321,000 for new property, plant and equipment. (See Table 2.) While applications for fast tax amortization do not cover the total projected capital expenditures of the nation's industries, they do give a good indication of the rate of expansion and reflect the relative ratio of capital expansion among the basic defense-supporting industries.

While the oil and gas industry in 1951 spent a record of about $3 billion for expansion, the total investments in new plants for which rapid tax write-offs were authorized between the fall of 1950 and the end of last February amounted to $1,117,749,000, or just under half of the industry's actual expansion. Estimates are that total petroleum industry capital expenditures for 1952 will exceed last year's volume.

Accelerated tax write-offs are provided in the Revenue Act of 1950. The provision authorizes the amortization over a five-year period specified percentages of the cost of new facilities certified by DPA as necessary for defense. Normally the period permitted for depreciation for new facilities varied up to 25 years, depending on the normal life usefulness of the facility. While this tax provision is purely a credit and over the life of a facility

TABLE 1

Leading Industrial Expansion Programs Aided by Rapid Tax Amortization

(Covered by Certificates Issued Through End of 1951)

SPECIFIC INDUSTRY CLASSIFICATION	Original Total Reported Cost* (000 Omitted)	REPORTED VALUE IN PLACE (Thousands of Dollars) Sept. 30, 1951	Per-cent	Dec. 31, 1951	Per-cent	ESTIMATED VALUE IN PLACE (Thousands of Dollars) March 31, 1952	Per-cent
Steel Works and Rolling Mills	$2,250,917	$691,903	31	$915,040	41	$1,117,036	50
Railroad Line Hauling Operations	1,271,466	792,632	62	976,774	77	1,120,859	88
Petroleum Refining	1,004,517	217,504	22	273,016	27	337,807	34
Electric Light and Power	855,386	319,725	38	415,696	50	475,281	57
Industrial Inorganic Chemicals	537,487	70,632	13	95,220	18	126,517	24
GRAND TOTAL, All Industries	$12,350,374	$3,904,823	32	$5,233,447	42	$6,364,865	52

Source: Defense Production Administration.

* Many industrial expansion programs have been enlarged since these costs were originally projected.

Petroleum refining industry expansion starting with July 1 will be greatly boosted due to larger allocations of steel to be made available to industry.

TABLE 2

Rapid Tax Amortization Certificates for Basic Industries

(Data Completed to February 25, 1952)

INDUSTRY	APPROVED BY DEFENSE PRODUCTION ADMINISTRATION: Number of Certificates	Proposed Investment	Tax Amortization Allowed	Percent Tax Amort. of Investment	PENDING APPLICATIONS: Number of Certificates	Proposed Investment
Transportation[1]	1638	$3,402,675	$2,226,381	65.4	1178	$ 937,327
Iron and Steel[2]	385	3,056,446	2,050,622	67.1	351	1,091,785
Chemical[3]	354	1,277,866	696,765	54.8	458	1,256,953
Electric Light and Power[4]	132	1,248,433	534,101	42.8	313	1,504,651
Petroleum	342	1,117,749	705,714	60.2	424	1,741,321
Non-ferrous Metals[5]	232	1,015,287	681,920	67.1	193	606,315

Sources: Industry totals tabulated from data of Defense Production Administration listing total Certificates of Necessity granted through February 25, 1952, and applications pending on that date.

[1] Includes all forms of transportation and terminal facilities except pipe lines.

[2] Includes iron ore facilities and all basic iron and steel making facilities with exception of plants for end products.

[3] All basic chemicals exclusive of pharmaceuticals and consumer products.

[4] Utilities only.

[5] Ore mining, primary smelting, refining, rolling, drawing and alloying facilities.

TABLE 3

Petroleum Industry Tax Amortization Certificates

INDUSTRY BRANCH	APPROVED BY DEFENSE PRODUCTION ADMINISTRATION: Number of Certificates	Proposed Investment (000 Omitted)	Tax Amortization Allowed (000 Omitted)	Percent Tax Amort. of Investment	PENDING APPLICATIONS: Number of Certificates	Proposed Investment (000 Omitted)
Crude Petroleum Prod.	2	$ 5,960	$ 5,054	84.8	2	$ 450
Natural Gas Production	2	4,083	2,706	66.3	12	30,760
Natural Gasoline Prod.	39	82,880	47,632	57.5	57	119,229
Drilling (Oil and Gas)	0	.....	.....	.....	1	4,036
Field Services (Contractors)	0	.....	.....	.....	1	120
Petroleum Refining	198	1,002,668	618,280	61.7	116	306,667
Oil Field Machinery and Tools	5	739	513	69.4	14	2,294
Crude Oil Pipe Lines	5	3,709	1,591	42.9	35	641,616
Products Pipe Lines	11	35,679	11,697	32.8	42	332,370
Natural Gas Transmission	5	3,512	1,428	40.7	12	105,862
Natural Gas Trans. and Distr.	0	.....	.....	.....	13	37,816
Natural Gas Distribution	1	180	126	70.0	17	114,354
Mixed Gas Distribution	1	95	66	69.5	1	300
Bulk Terminals	83	32,244	16,621	51.5	101	45,447
TOTAL	342	$1,171,749	$ 705,714	60.2	424	$1,741,321

generally does not represent any "saving" in total taxes after depreciation, it is a strong stimulant to aid private industry in financing its own expansion and to create capacity over and above that which normally would be provided to create a surplus of productivity for defense needs.

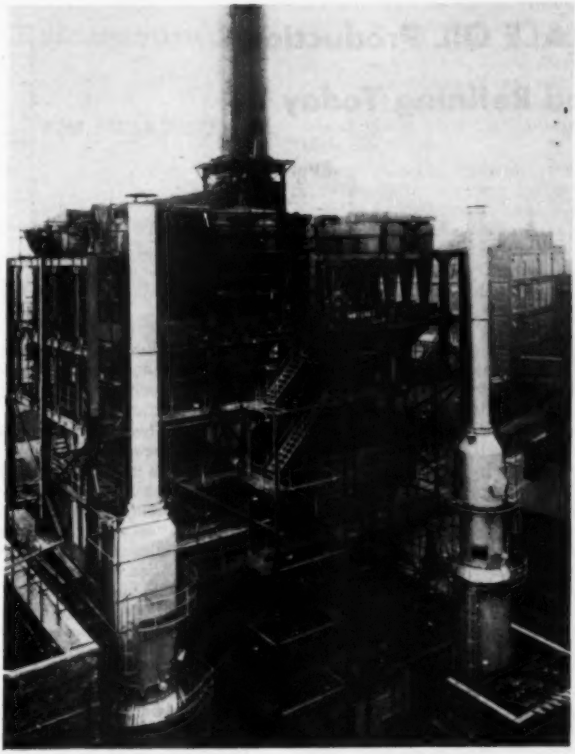
The Petroleum Administration for Defense projected expansion program for the oil and gas industry was to continue to build capacity for expanding civilian needs and to create a down-the-line reserve producing capacity of one million barrels daily by mid-1952. The target date was later extended by six months. With capital expenditures of $2.5 billion in 1950 and increased by $500 million last year, the industry made substantial additions to its productive capacity, though nearly all of this was required for immediate domestic demand increases and the sharp rise in U. S. export volume caused by the Iranian shutdown in mid-1951.

Despite the peak drilling and construction of new facilities in 1951, the industry at the end of the year had a margin of crude oil productive capacity over actual output of only 600,000 barrels daily. Much of this potential required completion of pipe line outlets to make it fully available. There was no measurable reserve refining capacity at the end of the year.

Petroleum's future capital expenditures, as indicated by requests for accelerated tax amortization (see Table 3), will spread the emphasis on new facilities to more branches of the industry. DPA in certifying rapid tax write-offs has granted approval of new projects on the basis of the most urgent needs for new facilities to support the defense build-up. Of the total of $1,171,749,000 in proposed investments approved for the oil and gas industry through February, $1,002,668,000 has been for refining facilities. With many of the most urgent expansion now approved, the industry now indicates its capital expenditures will be spread more evenly with crude oil pipe line projects scheduled to the largest items in company budgets. Crude lines for which rapid tax write-offs have been requested amounted to a proposed investment of $641,616,000 at the end of February, or more than one-third of the total.

Willingness of DPA to agree to greater emphasis on pipe lines can be seen in the latest list of accelerated tax amortization certificates approved during the first three weeks of March. Of the 10 largest individual certificates approved for all industry, eight were for petroleum industry pipe lines—two of which were natural gas lines.

Britain's New Catalyst Plant in Production



View of spray dryers of new petroleum catalyst plant constructed at Warrington, England, by Joseph Crosfield & Sons, Ltd., an affiliate of Lever Brothers & Unilever Ltd., under the technical direction of The Davison Chemical Corporation, Baltimore. Note dust collectors at top.

FULL scale production of petroleum cracking catalysts has been reached in the plant built by Joseph Crosfield & Sons, Ltd., an affiliate of Lever Brothers & Unilever, Ltd., at Warrington, England, according to advices received by R. L. Hockley, executive vice president of The Davison Chemical Corporation of Baltimore, whose processes are being used.

The plant is expected to produce at the rate of more than 10,000 short tons of catalyst a year, sufficient to process about 90 million barrels of petroleum, based on average refinery use of cracking catalyst.

The development was brought about through agreements with Davison and with five important oil companies which will use the catalysts in their refinery operations — Esso Petroleum Company, Ltd., Anglo-Iranian Oil Company, Ltd., Shell Refining & Marketing Company, Ltd., Trinidad Leaseholds, Ltd., and Bahrein Petroleum Company, Ltd.

Approximately one million pounds sterling has been invested by the British interests in the operation, which will save the United Kingdom several millions of dollars annually in dollar exchange. Davison, however, will be compensated in dollars for providing technical advice and guidance both in the building of the plant and its continuous operation.

The Davison process for producing the microspheroidal type of synthetic fluid silica-alumina petroleum cracking catalyst is employed at the plant. Part of the equipment used is two Swenson Evaporator Company stainless steel dryers. Swenson is also an American company but the dryers have been fabricated under license in Great Britain.

SHALE OIL Production And Refining Today

Part III

PETER W. SHERWOOD
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THE U. S. Bureau of Mines recently announced that it will build a much larger plant for the production and refining of shale oil. This project, together with the recent dangerous developments in Iran, has again placed the subject of shale oil in the limelight. The amount of crude oil available from U. S. shales is tremendous, and has been estimated in excess of 225 billion barrels.

Beginning with Part I on the occurrence and nature of shale oil, the series outlined the various retorting processes for shale oil recovery in Part II. Part III discusses the refining operations for converting the recovered shale oil into gasoline or diesel oil. As the key to the entire future of the shale oil industry, the economic questions on gasoline production from shale oil are discussed.

SEVERAL other tyes of oil shale retorts have found commercial application in foreign operations. These units are partly derivative of low-temperature carbonization ovens for coal and partly of special design for the retorting characteristics of the shales encountered in the various sites.

Scotland's shale oil industry has relied on the externally heated *Pumpherston* (circular cross-section) and analogous *Young* and *Broxburn* (rectangular cross-section) ovens. In common practice, four vertical retorts are integrated into one independently heated unit. Brickwork flues surround the retorts either spirally or horizontally and vertically, and into the lowest part of these, fuel gas is admitted from a common main. Only a portion of the total required combustion air is introduced at the base of the unit, the remainder being admitted through small ports along the side of the retort. Operation of these retorts takes place in batch-wise fashion. Tar recovery is between 85 and 90 percent of the Fischer assay. The investment cost of Pumpherston ovens is relatively high, but maintenance and operating charges are low. Operation of this unit is limited to shales with a high ash-fusion point.

The *Davidson* or *Goldfinch rotary kiln* has been employed in the carbonization of Estonian kukersite shale. This is a horizontal rotary kiln provided with internal scrapers which will prevent shale and coke from sticking to the walls through which heat is transmitted. Hubmann[1] states that oil recovery with this unit amounts to 92 percent of the Fischer assay. The oils are of very good quality with a high percentage of light oils (22 percent). Investment and maintenance costs for this unit are high, and the retort is only suitable for processing rich shales.

The *Pintsch* retort, which has been operated in Estonia since 1925, consists of a distillation section, separated —by means of a shale seal—from a spent-shale gasification zone underneath it. Green shale is fed to the top of the unit and descends gradually, first through the retorting zone where it is contacted by the hot gases leaving the gasification stage, and then through a restricted passage to the gasification zone. Here the spent shale is gasified by means of air and steam. The resultant producer gas is joined by cleaned recycle gas and the mixture passes to the carbonization section via special gas conduits. The purpose for recycling gas to the distillation zone is to increase the overall gas velocity and, hence, the heat transfer coefficient. Oil recovery is some 80 percent of the Fischer assay. Coking shales cannot be handled by this system, and operating difficulties due to obstructions in the flow of solid shale are not uncommon.

Tunnel kilns have been used industrially for the coking shales of Estonia. Flat cars carrying shale in thin layers (3 to 10 inches) are entered into a tunnel, which is subdivided into three zones (drying, distillation, quenching) by a system of locks. Movement of the cars through the tunnel is intermittent. Each position in the passage is maintained for about 7 to 14 minutes before the entire rake of trucks is moved forward to the next position. Drying is carried out by means of steam, generated in the drying operation itself and superheated in external heat exchange. Similarly, the gases and vapors evolved in the distillation zone are superheated externally and are partly recycled to impart their heat to the shale in process. The spent shale is quenched by means of water. Oil recovery is reported to average 96 percent of Fischer assay, but values as high as 98 percent are not uncommon. The process is simple and reliable but investment and labor charges are high.

Other foreign retorts which have aroused some commercial interest, but which differ from the above list of retorts only in detail, include designs due to Messel, Otto, Marecaux, Lurgi-Schweitzer, Lurgi-Hubmann, Fushun (an adaptation of Pintsch), etc.

Mention must be made in this connection of the suitability of high-pressure hydrogenation (and derivative "thermal solution") for the extraction of oil from shale in yields greatly exceeding the Fischer assay (which is, after all, a simple cracking process). Some attention has been given to this approach by the U. S. Bureau of Mines[2] and by Russian research.[3] Industrially, the process is not likely to be an economic success in view of the large amounts of ash which must be handled, and the costliness of the process.

Recovery of Shale Oil

A main cost item in shale retorting is the auxiliary condensers and gas washers provided for the recovery of the distillate. Investment costs in this part of the plant are particularly great in the case of internally heated retorts where the products are highly diluted by the carrier gases. Some alleviation at this point is attained in processes (such as the Kivioli tunnel kiln) in which the distillation gases themselves serve for retorting purposes and in which only a portion of the total process gas volume is withdrawn, cooled, and condensed.

Surface heat exchangers or quenching towers—or both—are provided for cooling purposes. Surface coolers have the advantage of keeping requirements on the subsequent distillation capacity

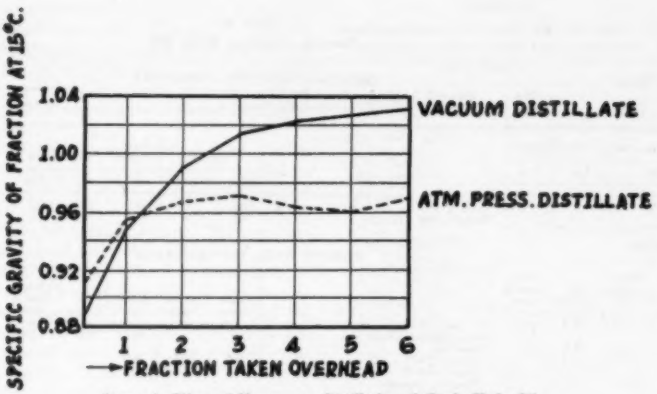

Figure 1. Effect of Vacuum on Distillation of Crude Shale Oil.

at a minimum but suffer from the fouling due to entrained solid particles and the large metal surfaces required for gas cooling. Where surface coolers are employed, a subsequent gas wash (by means of a hydrocarbon oil) is indicated in all shale oil processes to recover the volatile products remaining in the effluent gas. Depending on temperature conditions in the recovery system and on other operating variables, the gas washing operation may account for as much as five to twenty percent of the entire oil make.

Cooling by quenching is carried out in one or in two stages—cooling by oil injection only or cooling by oil injection followed by water quench (below 250° F.). Either method minimizes the formation of very severe emulsions which tend to form if water quenching is used throughout.

Problem of Emulsion

In the course of the retorting process, considerable quantities of water are distilled along with the desired shale oil. Part of this water is derived from incompletely dried shale while the remainder is formed by the thermal interaction of oxygen and hydrogen in the kerogen. In certain instances—especially where the specific gravity of the make-oil approximates 1.0—a very severe problem of emulsion formation is encountered in the low-temperature condensate. In some installations (e.g. the Estonian Pintsch retorting plant), the emulsion can be satisfactorily broken up by heating the entire liquid product to 140° F. and permitting it to separate at this temperature. In other cases, such simple methods are inadequate and a very serious nuisance problem is introduced. Proposed processes include costly salting out, cumbersome and costly solvent extraction, etc.

Results of studies on two methods of emulsion separation have been made available by the U. S. Bureau of Mines.[4] They are filtration in the presence of a filter aid precoat and passage of the emulsion through a bed of solids. Both methods appear to be effective but quite costly. (In the case of emulsion breaking of a heavy (20° API) shale oil by precoat filtration, a total cost of 5.8 cents per barrel was estimated.) Centrifuging has been employed to good advantage in breaking the emulsions formed by low-temperature carbonization (coal) tars, especially where the emulsion is stabilized by the presence of so-called "free carbon."

TABLE 1

		Percent	Specific Gravity
Overhead	Crude Gasoline	6	0.778
Tray Cut	Wax-Free Cut	23	0.816
Tray Cut	Possible Cut	56	0.890
Residue		15	0.960

TABLE 2

	CRACKING	
	To Coke Percent	To Residuum Percent
Gasoline	51	26
Residuum	..	51
Coke	29	..
Gas	15	9
Loss	5	4
	100	100

Cracking Shale Oil

In most instances, the ultimate objective in refining shale oil is the manufacture of a marketable grade of gasoline or diesel fuel. Yield of "straight-run" oils in the gasoline and diesel oil boiling point range is small and must be supplemented by cracking or hydrogenation operations.

Difficulties in cracking shale oil are formidable. The crude feedstock has a high specific gravity (around .95). Thus, the raw material already has the gravity (and carbon/hydrogen ratio) characteristics of the heavy fuel oils formed as by-product in the cracking of natural petroleum oils. Operation must, therefore, lead to the formation of a heavy residuum oil or to coke. Both types of cracking have been employed commercially for the processing of shale oils.

As practiced in Scotland,[5] advantage is taken of the relatively low thermal stability of shale oil (which is indeed to be expected of an oil containing some 0.5 to 1 percent sulfur and up to 7 percent oxygen). Primary cracking can thus be effected simultaneously and distillation of the crude, yielding a carbon-rich residue and a distillate more saturated than the crude oil. The operation is carried out at atmospheric pressure where the higher distillation temperatures result in increased cracking rates and consequently greater yield of diesel oil than would be obtained in vacuum distillation. (This effect is illustrated strikingly by Figure 1 which is based on work carried out by Luts[6] on the distillation of Estonian shale oils at atmospheric pressure and in vacuo.)

Scottish cracking-to-coke practice is carried out in a pipe-still and bubble-tower unit of conventional design. The products taken are as shown in Table 1.

Use of Pot Stills

The residue is cracked to coke in pot stills, operated in batch-wise fashion. The product is valuable for making carbon electrodes for the aluminum industry in view of its low volatility (5-7 percent) and ash content (less than 0.5 percent). Sometimes a coke of even lower volatility (as low as 1 percent) may be demanded. This calls for operation in some externally heated coking retort.

In processing shale oils of even higher carbon/hydrogen ratio than the Scotch products, cracking to coke becomes increasingly difficult and cumbersome. Luts[6] reports that the oil from Pintsch-retorted Estonian kukersite would yield up to 35 percent coke. Removal of such large quantities of coke from the equipment means high processing costs and discontinuity of operation. Under such conditions, it is therefore preferable to crack only to the formation of an asphaltous liquid residue. Contributory to the limited attractiveness of cracking to coke is the small market for this by-product.

Table 2, due to Boulzaguet[7] compares typical product yields obtained

TABLE 3
Visbreaking Shale Oil

TEST-PERIOD OPERATING CONDITIONS

CHARGING RATE: Raw Crude, Bbl./Stream Day 209.5
Recycle Stock, Bbl./Stream Day ..... None

	Heater		Flash Chamber	Fractionator	
	Inlet	Outlet	Top	Top	Btm.
Temperature, °F.	187	900	774	345	685
Pressure, psig.	290	120	13		

PRODUCT YIELDS AND PROPERTIES

	Crude Charge	Gasoline	Light Gas Oil	Heavy Gas Oil	Residuum	Gas, Coke & Loss
Yields, Volume Percent	100	9.7	19.8	44.3	24.4	1.8
Properties:						
Gravity, °API	20.6	51.1	31.1	21.6	11.5	
Pour Point, °F.	85		0	85	100	
Viscosity, Second:						
S.U.S. at 100° F.			38.6	109.5		
S.U.S. at 130° F.	127.5		35.0			
S.U.S. at 210° F.	45.9		29.6	45.0	287	
S.F.S. at 122° F.					998	
Sulfur, Weight Percent	0.85	1.06	0.84	0.72	0.69	
Nitrogen, Weight Percent	1.90	0.93	1.51	1.89	2.56	
Tar Acids, Volume Percent	1.6	2.0	3.0	1.8		
Tar Bases, Volume Percent	3.0	7.9	9.0	2.4		
Octane No.			29.0			
Octane No., M. M.		68.4				
Hydrocarbon analysis Olefins, Volume Percent		50.0				
Aromatics, Volume Percent		14.3				
Paraffins and Naphthenes, Volume Percent		35.7				
ASTM Distillation:						
I.B.P., °F.	362	111	257	517	196	
10 Percent at, °F.	493	194	448	633	322	
20 Percent at, °F.	561	246	458	652		
50 Percent at, °F.	632	316	498	692		
90 Percent at, °F.		370	573			
End Point Percent at, °F.		401	625			

TABLE 4
Recycle Cracking Shale Oil

TEST-PERIOD OPERATING CONDITIONS

CHARGE RATE: Raw Crude, Bbl./Stream Day 92.5
Recycle Stock Bbl./Stream Day 224.6

	Heater		Flash Chamber	Fractionator	
	Inlet	Outlet	Top	Top	Btm.
Temperature, °F.	460	910	755	385	632
Pressure, Psig.	930	150	52	....	....

PRODUCT YIELDS AND PROPERTIES

	Crude Charge	Recycle Stock	Gasoline	Residuum	Gas, Coke & Loss
Yields, Volume Percent	100	.....	50.3	46.2	3.5
Properties:					
Gravity, °API	21.1	16.8	54.4	5.5	.....
Pour Point, °F.	85	40	.....	80	.....
Viscosity, Second:					
S.U.S. at 130° F.	130.3	76.1	.....	.....	.....
S.U.S. at 210° F.	45.0	31.9	.....	257	.....
S.F.S. at 122° F.			.....	721	.....
Sulfur, Weight Percent	0.87	0.73	0.62	0.63	.....
Nitrogen, Weight Percent	1.88	2.52	0.97	2.87	.....
Tar Acids, Volume Percent			2.3	.....	.....
Tar Bases, Volume Percent			7.1	.....	.....
Octane No., M.M.			65.4	.....	.....
Hydrocarbon Analysis Olefins, Volume Percent			55	.....	.....
Aromatics, Volume Percent			15	.....	.....
Paraffins and Naphthenes, Volume Percent			30	.....	.....
ASTM Distillation:					
I.B.P., °F.	371	273	92	228	.....
10 Percent at, °F.	491	456	149	361	.....
20 Percent at, °F.	557	472	195	620	.....
50 Percent at, °F.	636	517	396	.....	.....
90 Percent at, °F.			400	.....	.....
End Point Percent at, °F.			411	.....	.....

in cracking a French shale oil by the two major methods.

A typical residuum cracking operation with shale oil is carried out in the liquid phase at 200-600 psi. Many installations prefer restricting heat transfer to the convective range to minimize the danger of coke incrustation due to local overheating in radiant heat transfer. Recycle operation is practiced in some instances. In this connection the Bureau of Mines reports the unexpected finding that the recycle oil at Rifle, Col., cracked quite easily and was not refractory.[4] As a result, clean cycle stock was available in only small quantities and coke deposition throughout the cracking zone was copious with resultant operating difficulties.

Facilities at Rifle, Colo.

The Bureau of Mines' demonstration plant at Rifle, Col., provides facilities for atmospheric distillation, visbreaking, recycle cracking, coking, and reforming. At the present state of knowledge, shale oil characteristics, notably the high nitrogen content, prevent the successful application of catalytic cracking techniques. Results of early visbreaking and recycle cracking runs are summarized in Tables 3 and 4.[4]

Egloff, Morell, and Zimmermann[5] have investigated the cracking of a number of crude and topped shale oils. They find that results are quite similar to those obtained in cracking petroleum, but that somewhat smaller yields are obtained for corresponding specific gravities. From the standpoint of cracking, the chief difference between shale oil and petroleum is stated to be the presence of oxygen- and nitrogen-containing compounds, generally grouped as tar acids and tar bases. These are corrosive to steel and require corrosion-protective measures. These materials also appear in the cracked distillates, resulting in undesirable properties, and they must be removed by treating methods to be outlined below, which result in relatively high gasoline losses. Gasoline yields obtained by cracking of the various feedstocks studied are summarized in Table 5.

Hydrogenation of Shale Oil

The large degree of unsaturation (around 50 percent olefins), and the plentiful presence of oxygen, sulfur, and nitrogen in shale oils suggest the use of destructive hydrogenation for converting this material to valuable hydrocarbon fuels.

TABLE 5

Feedstock	Mode of Cracking, Percent	
	Residuum	Non-Residuum (To Coke)
Manchurian	38.2	64.8
Australian	.....	59.2
Estonian, Crude	40.6	.....
Estonian, Topped Crude	26.1	.....
South African	43.8	.....
Swedish	42.0	.....

Advantages of this procedure are the very much higher yields which are possible by this method as compared to thermal cracking methods and the good octane numbers which can be attained in the product of hydrogenation. Overall gasoline yields may range as high as 95 volume percent. The main disadvantages are the high capital charges and the high cost of hydrogen.

When gasoline production is the objective, the process is carried out in two stages: primary conversion in the liquid phase followed by final refining in the vapor phase.

In both phases, the operating pressure has been industrially standardized at either 4400, or at 10,300 psi. Oils with relatively high amenability to hydrogenation, such as those derived by shale retorting, are processed to good advantage at the lower of these two pressures.

Most advantageously, the crude is topped for the removal of material boiling below 625° F. The overhead may be passed directly to the vapor phase or may be refined in other, more conventional, ways. The residue of the distillation is mixed with a recycle heavy oil and a suitable catalyst (iron sulfate and caustic soda impregnated

on some suitable carrier such as activated semi-coke ("grude"). Typical catalyst concentration is .5 to 1 percent (based on make-up oil) for a catalyst containing 5 percent ferrous sulfate and an equivalent amount of caustic soda.

The oil-catalyst mixture is boosted to reaction pressure and is preheated to 300° F. Somewhere along the preheating path, the feedstock is joined by high-pressure hydrogen. The mixture is introduced into the bottom of the first converter of a series of three or four. Passage through the reactors is continuous. The reactions involved are highly exothermic and serve to heat the process materials to the desired temperature range of 860-900° F. To prevent the attainment of higher temperatures (which will lead to excess gas and coke formation at the cost of liquid hydrocarbon yield), some means of cooling the system must be provided. Most commonly, cold hydrogen is injected into the converter at various points along the path of the charge.

Liquid Phase Function

The principal function of the liquid phase is to lower the molecular weight of the charge in a manner which will prevent the formation of refractory cracking asphalts and of coke. It will be noted that reaction conditions are in the range where shale oil will crack readily. Primary cracking products are postulated to consist of highly saturated and reactive molecular fragments which exhibit a strong tendency to repolymerization, resulting in the formation of heavy asphalt and even of coke. These repolymerization products are much more difficult to crack than the virgin stock and their formation will therefore result in yield losses and operating difficulties. By introducing a suitable catalyst into the liquid phase and applying hydrogen at a high partial pressure, it becomes, however, possible to hydrogenate the primary cracking fragments as soon as they are formed, thereby destroying their ability to repolymerize. In the case of shale oils, the formation of asphalts can be kept at very low values (not exceeding 2 percent).

The main products of the liquid phase are therefore lower-boiling hydrocarbons, to wit: fuel oil, middle oil, gasoline, and hydrocarbon gases. Formation of hydrocarbon gases means, of course, a loss in gasoline yield and a waste of costly hydrogen. Their formation can be reduced to the economically practical minimum by employing relatively mild time-temperature conditions. This means, at the same time, that gasoline production in the liquid phase will be lowered.

TABLE 6

Hydrogenation of Shale Oil Residues in the Liquid Phase with Finely Divided Catalyst.

Distillation Residue above 350° C. from Shale Oil	Paraffinic (Rich in H)	Asphaltic (Poor in H)
Specific Gravity at 15° C.	0.919	1.060
Asphalt, Percent	0.55	16.5
Paraffin, Percent	17.4	0.02
Ultimate Analysis:		
C, Percent	85.9	83.8
H, Percent	11.8	9.1
O, Percent	0.8	5.8
N, Percent	1.2	0.6
S, Percent	0.3	0.7
Yield in Liquid Phase Hydrogenation:		
Weight Percent Yield (middle oil and gasoline) on the Distillation Residue	91	88
Volume Percent Yield (middle oil and gasoline) on the Distillation Residue	98	105
Gasoline in the Product, Percent	11.0	19.6

This is in itself desirable, because the gasoline formed in this stage is of relatively low quality.

Operation of liquid-phase hydrogenation is therefore directed at the formation of middle oil (350-625° F.). Since middle oil, once formed, will be further split to gasoline under hydrogenative conditions, it is necessary to take a limited conversion per pass and to recycle heavy oils from which the middle oil (and smaller amounts of light products) have been removed by topping.

Table 6, due to Pier, shows some typical performance encountered in liquid-phase hydrogenation.[9]

Ideal Feed Stock

The middle oil derived from the liquid phase is highly saturated. About two-thirds of the oxygen and sulfur and one-half of the nitrogen in the crude shale oil will have been removed. The material is thus an ideal feed-stock for thermal cracking processes (but not for catalytic cracking because of the large amounts of nitrogen still present). If economics are favorable, it is possible to recycle the cracking residue to liquid phase hydrogenation where it is once more upgraded to a cracking feed stock.

An alternative method for converting middle oil to gasoline is to subject it to vapor-phase high-pressure hydrogenation over a fixed catalyst (pure WS_2 for primary refining followed by 10 percent WS_2-on-Fuller's earth and hydroforming for improving the octane number. Other catalysts have been employed to advantage but in more limited production). The product of vapor-phase hydrogenation is highly refined (substantially free of sulfur and nitrogen compounds) and requires only a dilute caustic wash. Probably because of the low quantities of sulfur present, the product gasoline has a high lead susceptibility and leaded octane numbers of 94 and even higher are readily attained.

Whether hydrogenation or cracking is to be preferred for shale oil processing must be settled on economic grounds. Information available to date is insufficient for a definite conclusion. By comparing the peculiarities of shale oil refining to the known factors of petroleum cracking and coal hydrogenation, there is an indication that a combination hydrogenation-cracking process, similar to the scheme outlined above, may well serve to good advantage in the conversion of shale oil to gasoline.

Refining of Shale Oil Products

Most of the refining operations employed in shale oil processing are taken directly from petroleum practice. This presentation will therefore be confined to the highlights of the more important operations applicable to this field.

Some paraffinic shale oils are characterized by the presence of relatively large amounts of wax in the "pressible cut (see above). This material can be recovered by cooling and filtration of the precipitated product. The wax so obtained in dark in color and unstable and requires treatment with sulfuric acid before it is sweated. Details of wax recovery from Scotch shale oils are reported by Smith and Peutherer.[5]

In the treatment of diesel oil and gasoline fractions, sulfuric acid is the most successful reagent. Treatment with 66° Bé acid results in losses which are considerably higher than is the case in the refining of petroleum oils. Commercial operation in several instances is therefore confined to the use of 85-90 percent acid. This reagent is adequate for securing improved color but odor specifications require an aftertreatment for the removal of residual sulfur.

The acid treatment must be preceded by a caustic wash for the removal of tar acids. This step is usually followed by a dilute sulfuric acid wash for the removal of tar bases (which possess a highly undesirable odor). This preliminary acid washing operation is desirable to minimize the amount of concentrated acid expended in the final treatment described in the preceding paragraph. A final neutralizing caustic wash completes this stage of the refining operations. Total refining losses due to treatment with alkali, sulfuric acid, plumbite, and redistillation range from 7 to 25 percent for the majority of thermally cracked shale oil gasolines.

The refining techniques here outlined apply only to straight-run and cracked gasolines. Products recovered

by the hydrogenation of shale oil are already highly refined and need only be subjected to a dilute caustic wash for the removal of residual hydrogen sulfide.

Economics of Gasoline Production from Oil Shale

The economic question is, of course, the key to the entire future of the shale oil industry. Three careful estimates have become available on the cost of producing various liquid fuels from Colorado shales.

Particular significance is attached to the National Petroleum Council's study of oil shale processing costs. The results of this work, which have been recently released, indicate that gasoline can be produced from shale oil for 14.7 to 16.2 cents per gallon. This compares with a present wholesale price of gasoline at the refinery averaging 12 to 13 cents per gallon.

TABLE 7

Summary of Cost for Producing Gasoline from Oil Shale

(National Petroleum Council Estimate—1951)

	(a) Single Plant	(b) Multi-Plant[5]
Shale: tons/calendar day	76,800	384,000
Products: barrels (42 gals.)/day:		
Gasoline	25,380	126,900
Diesel Fuel	12,200	62,360
Liquefied Petroleum Gas	1,780	8,920
Residual Fuel	340	3,050
Total Liquid Fuels, Barrels/day	39,700	201,230
Coke: tons/day	1,180	5,900
Fuel Gas (1060 Btu./Cu. Ft.) Standard Cu. Ft./Day	24,830	124,150
Chemicals:		
Ammonia, tons/day	92	460
Sulfur, tons/day	43	215
Manpower: Total, including supervision and administration	3,420	15,750
Construction Materials:		
Steel: thousand tons	178	694
Per daily barrel of Total: Liquid Fuel Production: tons	4.5	3.5
Construction Labor:		
Man-hours x 1000	26	123
Investment:		
Total—millions of dollars	333	1,518
Dollars per daily bbl. product	8,400	7,500
Cost of Gasoline with 6 percent return on Investment after Income Tax at 50 percent in cents per gallon	16.2	14.7

TABLE 8

Cost of Liquid Fuels Expressed as Dollars Per Barrel of Equivalent Gasoline

(Stanolind Estimate—1949)

	$ per Bbl. of Equiv. Gasoline
Direct Costs:	
Raw Material	1.725
Raw Material Transportation	.756
Processing	2.945
Product Transportation	....
Sub-total	5.426
Less By-Product Credits	.210
Total Direct Cost	5.216
Direct Cost plus 6 percent per year on investment for depreciation and interest	6.893 =16.4 ¢/gal.

Underlying the study is the Bureau of Mines' retorting technique. The crude shale oil is catalytically hydrogenated at 1100 psi and 835° F. and the product is treated by conventional refining means.

A breakdown of NPC's cost estimate is given in Table 7. Column (a) assumes the erection of a single plant, while column (b) is based on the simultaneous erection of five similar plants. The size of these units is defined in the table.

Stanolind Agreement

These figures appear to be in substantial agreement with a study published in 1949 by Stanolind Oil and Gas Company.[10] The results of Stanolind's study are summarized in Table 8. The estimate assumes the cost of mined and crushed shale at 88 cents per ton. Investment is estimated at $11,700 per daily barrel (1949 prices).

The underlying process involves Union Oil retorting, visbreaking, coking, reforming, and mild hydrogenation. Beyond this, numerous details of design and basic assumptions are not stated so that a completely fair comparison of this estimate with NPC's data is not possible.

Costs for the production of liquid hydrocarbons (primarily jet fuel and diesel oil) have been estimated by the U. S. Bureau of Mines for a 10,000-barrel-per-day plant. This estimate does not include any return on capital investment. It assumes the cost of mined and crushed shale at 43 cents per ton (30 gallons per ton). Investment costs are estimated at $4,670 per daily barrel of liquid fuel. The underlying process involves gas flow retorting, coking, and mild hydrogenation. The Bureau's figures are summarized in Table 9.

TABLE 9

Summary of Costs for Producing and Refining 10,000 Barrels Shale Oil Per Calendar Day to Yield Primarily Jet Fuel and Diesel Oil

(U. S. Bureau of Mines Estimate—1949)

	$ per/bbl. of Liquid Fuel
Cost of Operation and Maintenance:	
Refining	0.756
Pipe Lines	0.006
General Facilities Chargeable to Refining	.139
Utilities Chargeable to Refining	.215
Total Direct Refining Costs	1.118
Other Refining Costs (Amortization, Depreciation, Taxes, Insurance)	.506
Gross Cost of Refining	1.624
Cost of Crude Shale Oil	1.694
Gross Cost of Liquid Fuels	3.318
Less By-Product Credits:	
Ammonia at $75 per ton	0.229
Coke at $3 per ton	.021
Net Cost of Liquid Fuels	$3.068 =7.41 ¢/gal.

End of Part III and series.

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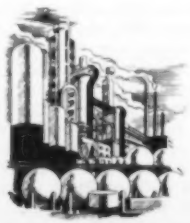

Piping manifolds may be insulated as a unit for high efficiency, sturdy construction, and pleasing appearance.

Properly Designed Thermal Insulation Can Earn Big Investment Returns

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The M. W. Kellogg Company, Jersey City, N. J.

THE PRESENT necessity of substitutions and replacements, so prevalent in most industrial essentials, has not escaped the field of insulation. Scarcity of well-known insulation materials such as magnesia and diatomaceous silica, principally used in the medium and high temperature field, and vegetable and mineral cork in the low temperature field, has forced the industry to look elsewhere for suitable substitutes.

During and after World War I, the demand for most commonly used products in other fields forced insulators to develop mineral wool blankets, blocks and pipe covering to a much greater degree than before. Now a similar situation exists and the introduction of new types of insulating materials must take into consideration their value from an investment standpoint, as the true worth and soundness of any investment must be measured by its yields and freedom from risk and extra assessments.

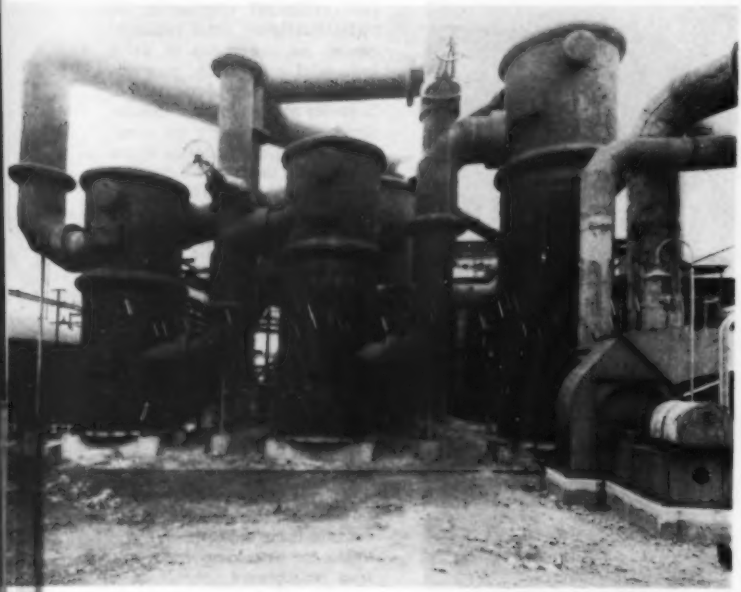
THE technology of insulation rarely receives the attention and consideration it rightly deserves because it is generally regarded as technically unexciting and its cost on the job not too apparent. The reasoning behind this lethargic lack of consideration of insulation is unsound because a review of its cost should call attention to itself with sufficient effect to create a decided issue.

Various plants requiring insulation consist for the most part of an assemblage of apparatus containing hot fluids, gases, etc., and their operation would be practically impossible without insulation. Additionally, it is insulation which prevents the cost of heat or refrigeration from being prohibitively high. Insulation is so efficient that it can be made to pay almost any desired return on investment; moreover, it greatly reduces operating hazards and makes working conditions bearable, despite heat or cold. While engineers usually profess to have little regard for appearance, they frequently give it a great deal of consideration. Anyone looking about in an oil refinery is looking at insulation as a rule, and a good job calls attention to itself; so does a bad one.

Three Factors Involved

Fundamentally there are three factors that can take place in the transfer of heat—by conduction, by convection, and by radiation. By the application of scientifically designed insulating materials we may reduce the heat loss through a boiler wall to a minimum, thus conserving available energy to do useful work and at the same time lowering operating costs and improving working conditions.

But what are scientifically designed insulating materials? How do we know such materials will conserve heat? And if so, will the resultant savings in fuel cost justify the expense of insulation? The answers to these questions lie in what science is today accomplishing in the art of heat conservation through insulation.



Here is a good example of well designed and properly installed insulation.

The conductivity of a material is, of course, the factor which determines insulating efficiency. The designer should choose the type insulation best suited for any specific job, as well as the most economical thickness.

No one or two types of material can be expected to serve under the wide variety of conditions insulation is called upon to meet today. For example, the temperature may be 200° F. below zero or 3000° F. The surface to be insulated may be pipe, tank, housing or a furnace floor, wall, roof or door. The surface may be regular in contour, or broken up with projecting fittings or accessories. The insulation may be indoors or outdoors.

Because heat is valuable energy, insulation, which saves heat, is an investment. It has other functions but its chief use is to save money. If it is bought, as it should be, according to rules which govern the purchase of other equipment, such as machinery, it pays a large return on expenditure.

Return on Investment

When we contemplate the purchase of a machine, we compare the probable return on the investment with the cost required. If the norm is met or exceeded, the purchase is justified; if not, the expenditure is not warranted. The same comparison is made in the case of insulation but because the material is available in incremental thicknesses, and because each increment has its own individual earning power, we must consider a series of individual purchases rather than just one, where we wish to determine, for instance, the proper thickness of pipe covering to use for any one set of conditions.

Several very effective methods have been worked out to determine the most economical thickness for any set of conditions, but in practice because of the many variables and the resultant tediousness of the calculations, the thicknesses used are those given in tables published by the insulation manufacturers; these are not tables of inadequate thickness.

The minimum commercial thickness of insulation is likely to pay a large return, and if the temperature of the insulated surface is great, a tremendous return, perhaps as much as two or three thousand percent, will result. If we add a commercial increment to the first thickness, the cost of that increment will probably be less than the first, but the additional saving of heat will be relatively small, so that the return diminishes markedly. If we continue to add increments until the one fails to bring the desired return, then that is the one which we do not buy. The rule is, of course, that we will not invest any dollar which fails to bring our required return. The return consists of all charges against the insulation, such as depreciation, interest, etc., and will vary according to customer and plant. For temperatures below 500° F., two increments will probably suffice; at 1000° F. five or six may be required.

Take for example the case of 3-inch pipe operating at 800° F. Assume that the heat in the pipe costs 40 cents per million Btu and that a 50-percent return is required. In order to work out the most economical insulation we must know the applied cost of several thicknesses, from which we get the incremental cost, and the heat loss for each thickness, from which the incremental saving in heat is obtained. Assume that this information is as shown in Table 1 all items being for one foot of pipe.

TABLE 1

Insulation Thickness Inches	Insulation Cost Dollars	Incremental Cost Dollars	Incremental Savings of Heat Btu./Ft./Hr.
1	1.30	1.30	1" over bare pipe—6962
1½	1.60	.30	1½" over 1"—126
2	2.02	.42	2" over 1½"—58
2½	2.73	.71	2½" over 2"—48

Then the saving due to 1" of insulation in a year of 8700 hours is:

$$\frac{6962 \times 8700 \times 0.40}{1{,}000{,}000} = \$24.20$$

and the return on investment is:

$$\frac{\$24.20}{\$1.30} \times 100 = 1870 \text{ percent}$$

The additional return on the next increment, from 1-inch to 1½-inch is:

$$\frac{126 \times 8700 \times .40 \times 100}{1{,}000{,}000 \times .30} = 146 \text{ percent}$$

In the same way, the next increment (2-inch over 1½-inch) will pay 48 percent, which is so close to 50 percent that it should be bought. The increment from 2-inch to 2½-inch, however, pays only 24 percent, which is too small.

The calculation of correct thickness is complicated because of the many variables: fuel cost, return, pipe size, insulation thickness, weather conditions, cost of insulation and the conductivities of the various materials available. Discrete selection of average values will, however, permit some simplifications.

Insulation Requirements

The same holds true for cold insulation but other factors enter into such a study, mainly a good vapor seal during and after application. Proper installation of cold insulation is of paramount importance. Special care shall be taken to minimize direct heat flow from one side of an insulated partition to the other through metal to metal or similar contacts.

Generally the standards for quantity of insulation recommended for oil refinery equipment have been for the

most part established by insulation manufacturers, the basis for the quantity being the economical thickness of insulation for power plant steam generating units. The longer life and higher value of generated heat for steam power plants has set these thicknesses much in excess of that generally required for oil refinery equipment, where heat must be partially or entirely removed by water cooling. An excessive quantity of insulation applied to such equipment not only adds fixed charges to the equipment but also means an increased operating expense in the larger quantity of water required for the removal of the heat retained by the thicker insulation.

The purpose of insulation requirements as applied to oil refining equipment may be summarized as follows:

1) Prevention of heat loss required for process purposes.

2) Prevention of heat loss required for positive control purposes.

3) Reduction of temperature stress.

4) Fire protection.

5) Protection of personnel.

Cold insulation should be based upon a consideration of:

1) Process refrigeration conservation.

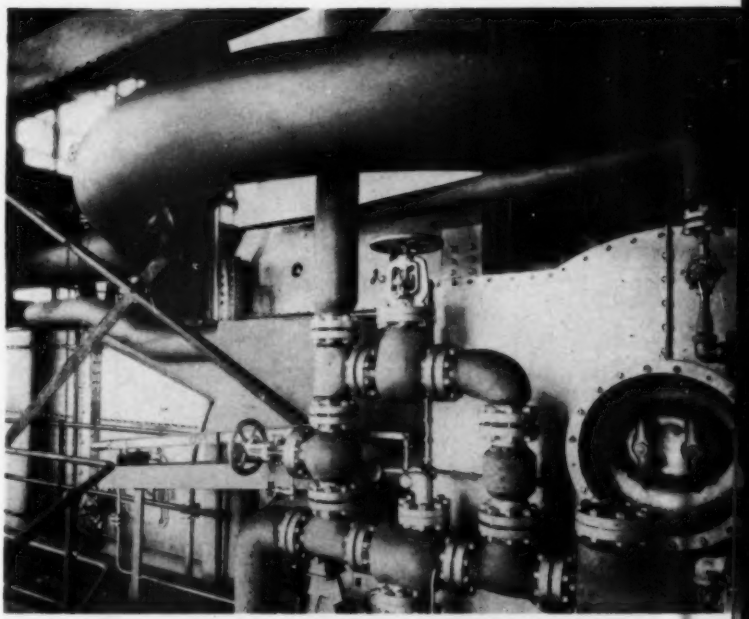
2) Prevention of condensation and sweating by maintaining the outside temperature above the dew point.

The refineries are meeting all of the increased factors of demand with a well-integrated plan for plant improvement and expansion. Temperature and pressure control effects both quality and quantity also increases the normal yield of salable products.

For oil refining equipment, insulation is essential to certain parts for the purpose of preventing loss of heat necessary for proper processing. Reactors, regenerators, coke drums, fractionators, evaporators, vacuum towers, heat exchangers and the piping transferring fluids, gases, catalyst, etc., whose heat is required for further processing, are examples of such parts. Insufficient insulation applied to this equipment permits an excessive heat loss which in turn requires greater heat input to maintain the proper operating temperature.

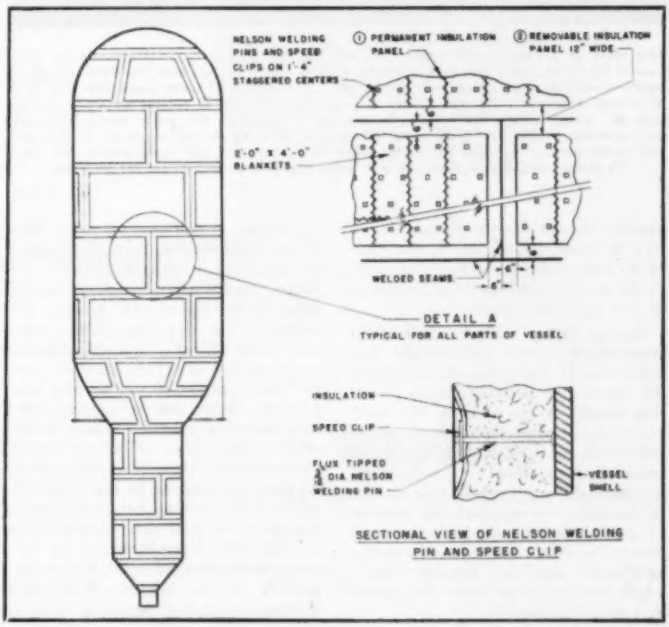
A fair basis for establishing the amount of insulation, therefore is the cost of the heat input, unless the heat necessitates raising the temperature sufficiently to affect the operation by forming coke, etc. Under such conditions the basis for establishing the thickness must be one in which the temperature rise is kept low enough to reduce the possibility of this difficulty.

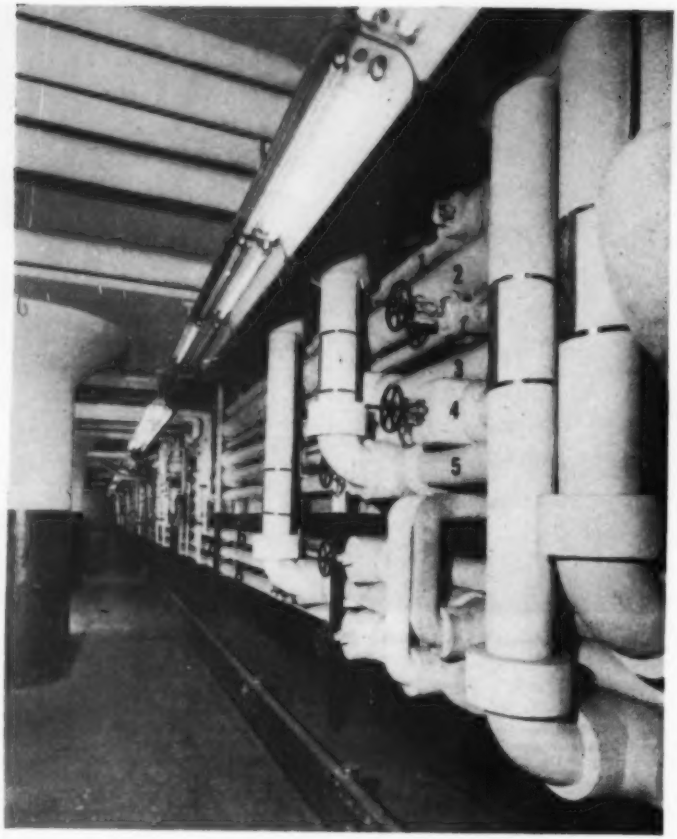
The amount of insulation required for fractionating towers depends upon 1) the degree of fractionation, 2) the



In certain instances it may be desirable to leave flanged joints bare for easy access.

Figure 1 (below). Insulation for Vessels Requiring Stress Relieving and Weld Seam Inspection. Notes: 1) Permanent insulation Panels. 2) Temporary blanket insulation shall be installed in twelve-inch wide panels and held in place with No. 16 BWG. wire laced between the metal reinforcing of the adjoining permanent panels. 3) After stress relieving, removal of temporary insulation, and inspection of weld seams, the twelve-inch wide panels shall be insulated in the manner specified for the rest of the vessel.


NELSON WELDING PINS AND SPEED CLIPS ON 1'-4" STAGGERED CENTERS
① PERMANENT INSULATION PANEL
② REMOVABLE INSULATION PANEL 12" WIDE
2'-0" X 4'-0" BLANKETS
WELDED SEAMS
DETAIL A
TYPICAL FOR ALL PARTS OF VESSEL
INSULATION
SPEED CLIP
FLUX TIPPED 1/4 DIA NELSON WELDING PIN
VESSEL SHELL
SECTIONAL VIEW OF NELSON WELDING PIN AND SPEED CLIP



This maze of piping supplies steam, air, and hot and cool water to manufacturing units. Careful layout of piping and proper spacing of lines allows for full insulation thickness at all points—results in neat looking and efficient job. 1) Three-inch 50-pound steam line—std. thick 85 percent magnesia. 2) Six-inch 300-pound steam line—dbl. std. 85 percent magnesia. 3) Four-inch 40° water return—light-duty cork covering. 4) Four-inch 40° water supply—light-duty cork covering. 5) Four-inch 200° water return—std. thick 85 percent magnesia. 6) Four-inch 200° water supply—std. thick 85 percent magnesia. 7) Four-inch 200° water return—std. thick 85 percent magnesia. 8) Four-inch 200° water supply—std. thick 85 percent magnesia.

amount of heat recovered from the reflux or cooling medium, 3) the ratio of the heat exchange of vapor to reflux to the heat lost through the insulation at any particular point.

Heat exchange with the shell of the fractionating vessel reduces the tray reflux above the point of cooling by the amount of this heat exchange. If this should be appreciable, the tendency would be to reduce the amount of reflux induced at the top of the column below that required for proper fractionation. Where a reasonable amount of insulation is applied, the amount of such heat loss through the shell affects the reflux very little excepting equipment such as vacuum vessels which have a large ratio of exposed surface to thruput.

Climatic conditions influence insulation requirements. Wide fluctuations of atmospheric temperature, for instance, may make processing control difficult. In places like Abadan, for example, the day time temperature may reach 125° F., the night temperature may fall to 50° F. In states such as Texas and California, sudden temperature drops due to chiling rains may overolad automatic control. The effect of such great or sudden temperature changes may be minimized by adequate insulation. In very cold climates it is obvious that more insulation must be used than elsewhere, as in Edmonton, Canada, where the temperature approaches —40° F. for long periods in the winter. With such weather insulation must be heavier and more extensive. For uniformity of process control each individual case must be analyzed to determine the maximum range of the controlling equipment and the maximum variation in heat loss due to these climatic changes. The greatest difficulty with erratic control has been experienced with the cooler parts of equipment considered unnecessary to insulate. The bare surface exposed to rain, wind, sun or sudden change in temperature produces a large variation in heat loss. In such cases very little insulation is required to provide control. One inch of thickness in most cases will decrease the heat loss and variation approximately 90 percent.

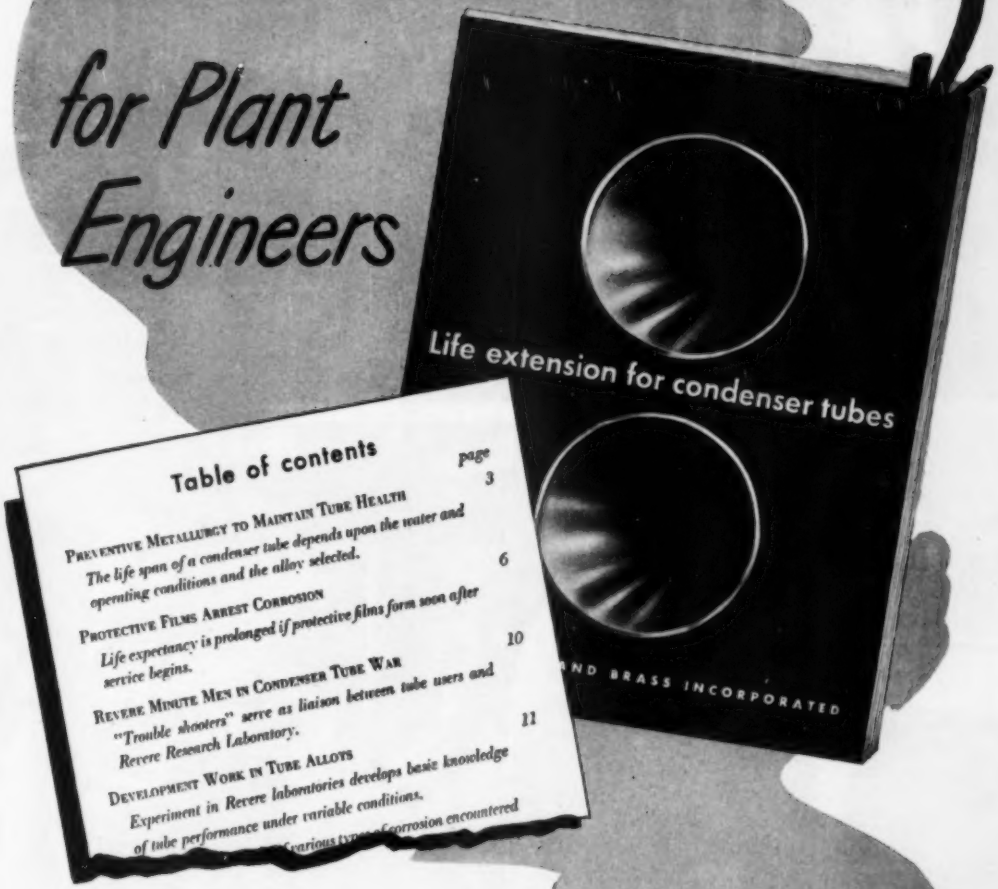
Insulation requirements for fire protection of oil refinery equipment containing hot oil, gases, or equipment subject to a fire hazard should be protected by insulation. The purpose of this insulation is two-fold, namely: 1) to protect the equipment from rise in temperature which will cause failure due to reduced strength, and 2) in case of fire, to reduce the heat transfer into the vessel to a rate at which ordinary pressure relief equipment will relieve the vessel of the excess pressure created by the addition of heat.

Insulation is required for the protection of personnel against hot surfaces of equipment and piping adjacent to parts of the unit where the possibility of contact may result in serious injury to operators. Surface temperatures which cause burns vary with different materials. A metal temperature of 175° F. and above will readily cause burns, whereas an insulated surface will prevent the same degree of burn at approximately 250° F., depending upon the surface and conductivity. The amount of insulation which should be applied on metal surfaces which are above 175° F. should be of sufficient thickness to reduce the outside temperature below 250° F.

Insulation applied to the hot side of a metal structure will reduce its temperature, thereby permitting higher stress in the metal and consequently the use of less metal. This saving is frequently of considerably greater value than the cost of insulation, which may often be quite thin as well as effective.

An effort has been made to show that insulation deserves a more important part in the economy of an industry where the problem of heat conservation is paramount. It has been proven that by a judicious application of insulation the lowering of fuel requirements have resulted. This represents a saving which is so vital in the present time of accelerated price rises.

"MUST" Reading for Plant Engineers


Life extension for condenser tubes
AND BRASS INCORPORATED
Table of contents
page
PREVENTIVE METALLURGY TO MAINTAIN TUBE HEALTH
The life span of a condenser tube depends upon the water and operating conditions and the alloy selected. 3
PROTECTIVE FILMS ARREST CORROSION
Life expectancy is prolonged if protective films form soon after service begins. 6
REVERE MINUTE MEN IN CONDENSER TUBE WAR
"Trouble shooters" serve as liaison between tube users and Revere Research Laboratory. 10
DEVELOPMENT WORK IN TUBE ALLOYS
Experiment in Revere laboratories develops basic knowledge of tube performance under variable conditions. 11

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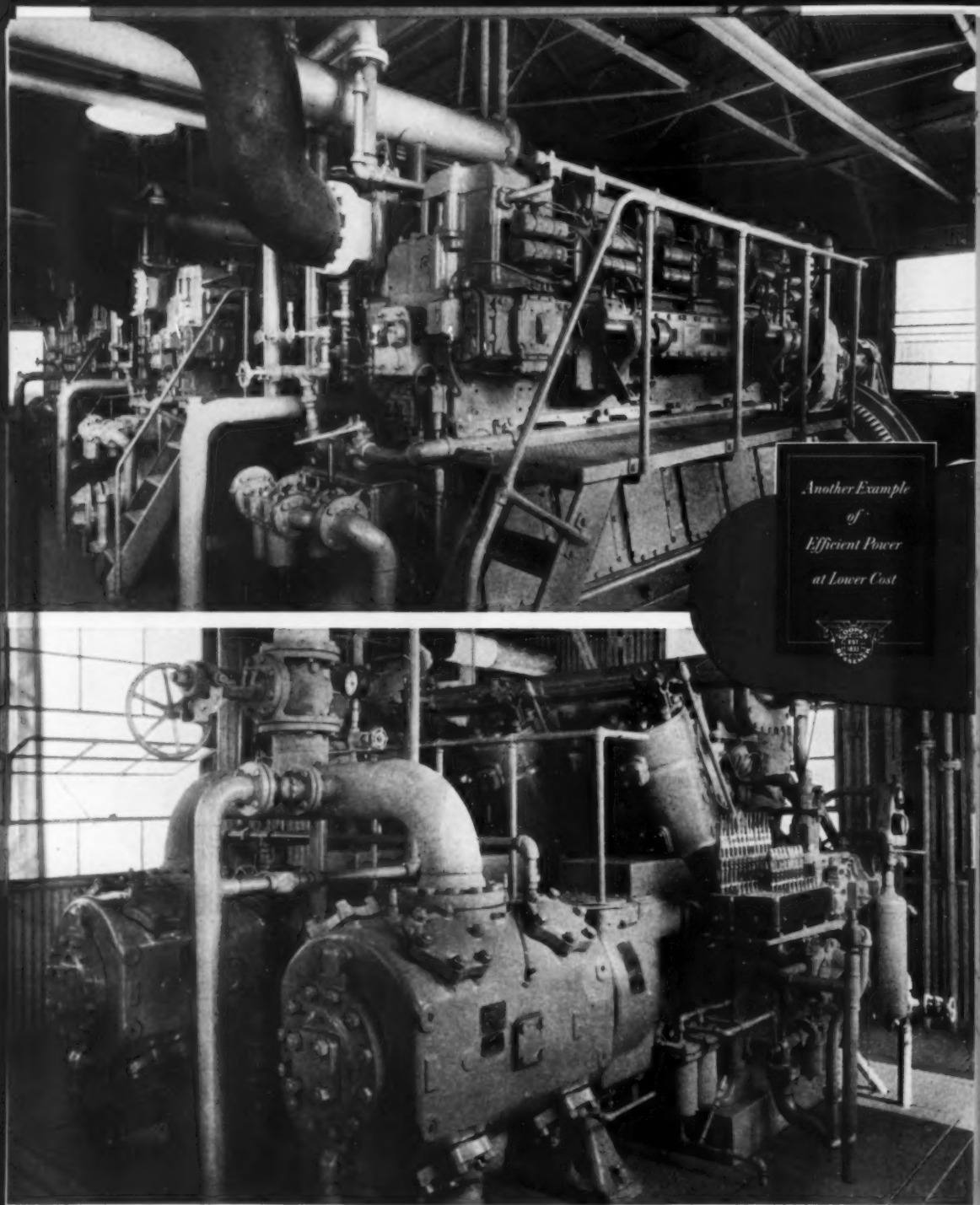

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HUGOTON PLAINS GASOLINE PLANT

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The new natural gasoline plant of the Hugoton Plains Gas and Oil Company, now operating about a year, is powered by the Cooper-Bessemer units shown opposite. These consist of three JS-6 540 hp gas engines driving 368 KW A.C. generators, and a 308 hp GMX V-angle compressor.

This interesting field processing plant, engineered and constructed by J. F. Pritchard & Company, serves 176 gas wells, operates without steam, and efficiently produces natural gasoline, propane, butane and iso butane. Residue gas goes into Northern Natural's system.

The three JS gas engines operate 24 hours a day, furnish all electric power required to operate the plant. Using Cooper-Bessemer's latest development in high compression operation, these modern engines attain 34.4% thermal efficiency, holding fuel consumption to less than 7400 BTU/bhp/hr.

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REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the processing industry.

Four-Man Report On Destrehan Hydroformer

The four engineers who co-authored "Destrehan Fluid Hydroformer Scheduled for Operation," apparently found distance no object in compiling the top-notch report on page 114. James A. Bock and John F. Snuggs are stationed at the Whiting, Ind., offices of Standard Oil Company (Indiana); Dr. John W. Bertetti is with Pan-Am Southern in New Orleans, and Dr. James E. Seebold is with the Chicago Indiana Standard offices. Seebold, assistant manager of research, is an ex-professor of chemical engineering at Massachusetts Institute of Technology, from which he holds a doctorate in chemical engineering. He joined the Whiting research laboratory in 1940 and was recently transferred to Chicago.

Bertetti is assistant general manager of manufacturing for Pan-Am in New Orleans. He holds degrees from the University of Illinois and the University of Michigan in chemical engineering. He joined the Whiting research laboratory of the Standard Oil Company (Indiana) in 1934, and was transferred in 1936 to the research department of a subsidiary, Pan American Refining Corporation at Texas City, Texas. He joined Pan-Am Southern in 1942 and assumed his present position in 1951.

John Snuggs joined Indiana Standard in 1938 and is section leader in the process division of the research department at Whiting. He holds degrees from Stanford University and Massachusetts Institute of Technology. James Bock is group leader in the process division of the research department at Whiting and is a graduate of Purdue University and MIT. He joined the company in 1943 and assumed his present position in 1948.

AIC Honor Scroll Award to Go to Dr. Foster Dee Snell

The Fourth Annual Honor Scroll Award of the New York chapter of the American Institute of Chemists will be presented this year to Dr. Foster Dee Snell, president of Foster Dee Snell, Inc., consulting chemists. The Honor Scroll, given annually for outstanding contributions to the profession of chemistry, will be presented to Dr. Snell at a dinner meeting in New York, May 22.

Read Has Been UOP Engineer for 14 Years

Davis Read, author of "Production of High-Purity Aromatics for Chemicals" on page 97, has been doing chemical work for Universal Oil Products for some 14 years, and during that time he has done everything from research to economic evaluations. Currently a member of the commercial development department at UOP, Read graduated from Purdue University in 1936 with a B. S. degree in chemical engineering. He landed a job with Reilly Tar and Chemical Corporation at Indianapolis where he worked for about a year before returning to the campus for more academic work. This time he spent a year at the University of Michigan, working toward a M. S. in chemical engineering. In 1938, Read joined UOP and has been with the company ever since. His work has been in various phases of research and development, including pilot-plant investigations. In the service department during 1943-45, he was engaged in the operation and supervision of 100-octane gasoline plants which were UOP's responsibility in the war program. Since 1945, Read has been especially active in work involving economic evaluations and planning of refinery projects for changing marketing conditions.

Dunn, Liedholm Tell About Shell Process

The report "Shell Process Permits Recovery of Nitration Grade Benzene and Toluene" on page 104, is the product of two men long active in Shell Development Company's engineering and chemistry departments, George E. Liedholm and Clarence L. Dunn. Liedholm, assistant head of Shell's process engineering department, graduated from California Institute of Technology in 1931 in applied chemistry. After two years with Procter and Gamble in Long Beach, Calif., he joined Shell Development Company in Martinez, and has been with this organization since that time. He has been active in process design of catalytic cracking and catalytic reforming plants and in synthetic liquid-fuels projects. During World War II, he served as a member of the Toluene Technical Committee which was empowered with the technical guidance of all toluene producing facilities.

Dunn, a graduate of the University of Washington and California Institute of Technology, spent a short time with du Pont before joining the Emeryville laboratories of Shell Development. In 1939, he was one of the inventors of the Shell extraction distillation process for recovery of aromatics. His primary interest has remained in the development of separation processes applied to both the petroleum and chemical field. He is currently assistant head of Shell Development's physical chemistry department.

Arosorb Process Is Trio's Main Interest

Naturally enough, the Arosorb Process is the primary interest of the trium-

Dr. J. E. Seebold | J. F. Snuggs | J. A. Bock | J. W. Bertetti | Davis Read

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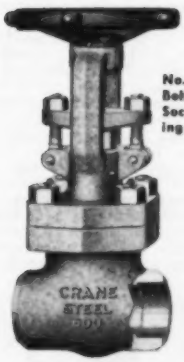

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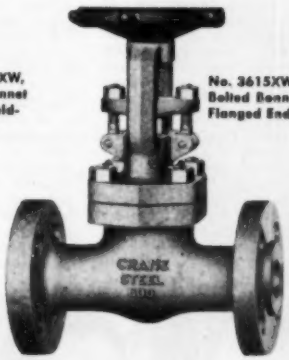

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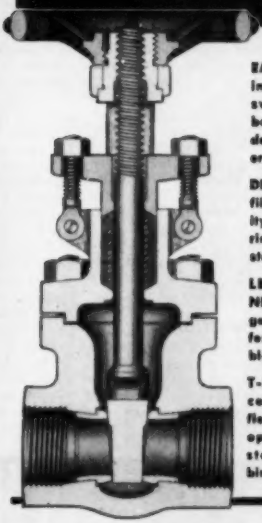

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virate who produced "The Arosorb Process In Refinery Operations" on page 109. William H. Davis, James I. Harper and Earl R. Weatherly, all Sun Oil Company men, who have been intensely active in the design and development of Sun's aromatic facilities which will utilize the first commercial applications of both the Arosorb and Houdriforming processes. Davis is presently process engineer in Sun's manufacturing department in Philadelphia. After completing his academic work at the University of Michigan in 1939, he was employed by the Bechtol-McCone-Parsons Corporation, joining Sun in 1944. Currently he is engaged in the process design of Sun's aromatics plant.

Weatherly is a process engineer in the research and development department at Marcus Hook, Pa., where he has worked for five years. He graduated from North Carolina State College in 1947 after having his academic studies interrupted by the war, during which he served in the U. S. Air Force as a major. He started at Sun in 1947, and has been active in the development of the Arosorb process since then. He has several patents on file in this field.

A Rensselaer Polytechnic Institute graduate, and also at Marcus Hook Harper taught for two years before going to work for Atlantic Refining Company. He joined Sun in 1936 and during World War II, he was active on the Synthetic Subcommittee of PIWC Technical Advisory Committee. He is an A. I. Ch. E., ACS and AAAS member.

Sunkel Elected by Atlantic

The Atlantic Refining Company has announced the election of L. A. Sunkel as vice president. He has also been appointed general manager of crude oil production for Atlantic. Sunkel has been with Atlantic for 33 years.

Engineers Collaborate On Commercial TCR

Four men, all closely associated with major developments in the refining industry during the last 20 years, collaborated to turn out the article "TCR Reaches Commercial Stage—Details on Thermofor Catalytic Reforming Revealed" on page 117.

Although all four men are with Socony-Vacuum Company, Inc., perhaps the one most closely associated with TCR is Eric V. Bergstrom, who for the past nine years has worked on the development and mechanical design of So-Vac's Thermofor catalytic cracking, pyrolytic cracking, reforming and percolation equipment, and with catalyst manufacturing equipment. A graduate of the University of Illinois, he holds many patents in these fields. Bergstrom is chief design engineer for Socony's refinery engineering division.

Graduate of Yale

John W. Payne is technical director of the development division of Socony-Vacuum's research and development laboratories at Paulsboro, N. J. He received his B. S. degree in chemical engineering from Yale University in 1930 and spent one year with the Swann Chemical Company in research before accepting his current position.

Vernon O. Bowles is chief process engineer with Socony's refinery engineering division at New York where he supervises the process design of major refining installations in Socony's refineries. He has been closely associated with the development of the Thermofor catalytic cracking process from its early stages and more recently with the development of the Thermofor catalytic reforming process.

During his 20 years with Socony, Louis P. Evans has been associated with the development of many important refining processes in use by the petroleum industry today.

These include furfural refining, solvent dewaxing, coking and other thermal processes, catalytic cracking and, more recently, catalytic reforming. He has received numerous patents in the field of petroleum refining, and has also made extensive contributions to the technical literature in this field.

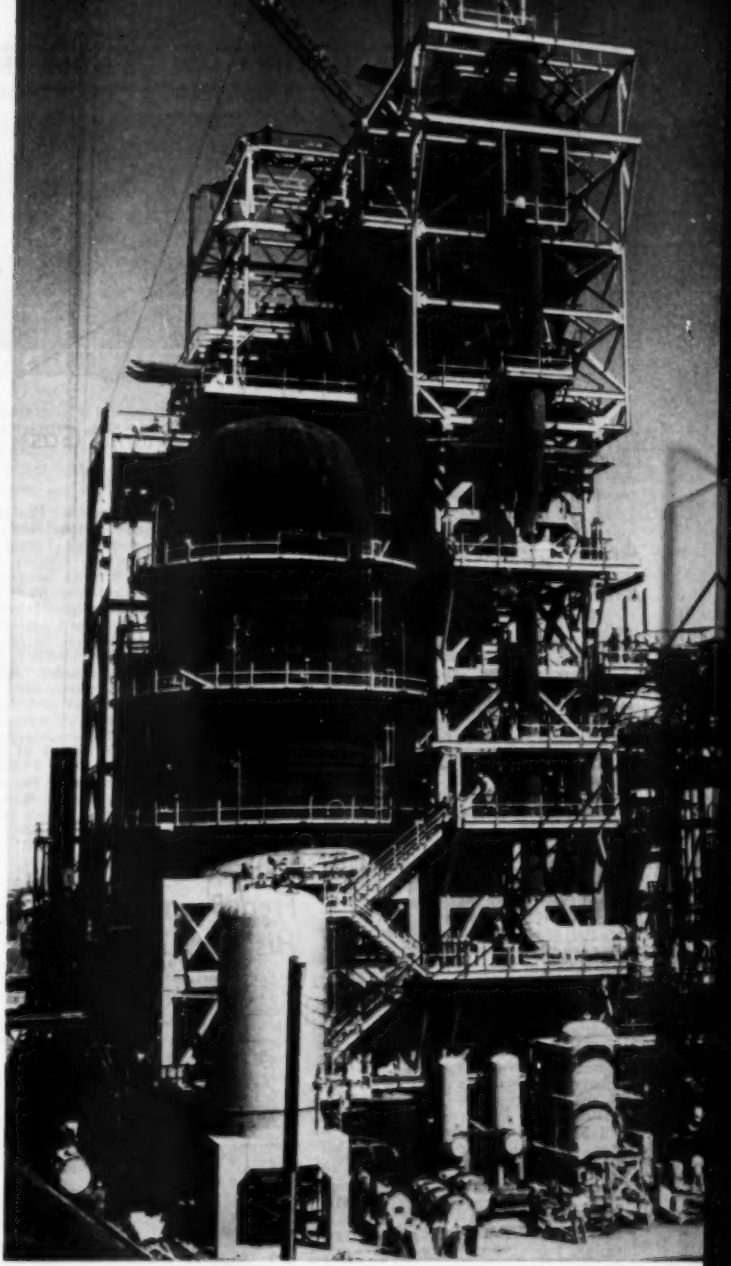
Gall Sleuths Unusual Insulation Problems

The author of the article on page 165 "Necessity of Thermal Insulation and Required Return on Investment," probably got a lot of moral support in pursuing his hobbies of boxing and swimming, for John T. Gall is the father of three boys, and also has one grandson. In addition, he and his wife have one daughter. Gall's other hobbies include playing the violin, and ramrodding the organization of The M. W. Kellogg orchestra to entertain at the company's annual dinner.

A registered professional engineer in New Jersey, he received his education at Cooper Union, and has completed a refinery course conducted by Tide Water Oil Company, and an extension course in oil refinery work at Rutgers University. During his professional career, Gall has been connected with Tide Water Oil Company, and has been a member of The M. W. Kellogg Company for the past 25 years. His experience has included many phases, from piping and structural design to insulation specialization, and he has prepared insulation design and material specifica-

E. V. Bergstrom | L. P. Evans | V. O. Bowles | J. W. Payne | J. T. Gall

NEW PACIFIC COAST FLUID CAT ★ CRACKER



THIS new 28,500 B/D Fluid Catalytic Cracking Unit nearing completion at Wilmington, California, is being built by Arthur G. McKee & Company for the Union Oil Company of California.

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Dr. R. F. Aries | R. M. Cziner | I. E. Nutter | H. F. McConomy | J. J. Hur

tions for all types of chemical and refinery units. In addition he has specialized as a consultant in solving unusual insulation problems.

Aries, Cziner Have Mutual Interests

Dr. Robert S. Aries and Rudolf M. Cziner, who co-authored "Acetylene—The Newest Petrochemical" on page 127, share more than an interest in chemical engineering. Both men have taken time off from their regular duties to delve into the business and economic end of the field. Aries, in addition to heading the well-known, world-wide consulting engineering organization of R. S. Aries & Associates, finds time for his "hobby" of teaching, being Adjunct Professor of chemical engineering at the Polytechnic Institute of Brooklyn where he "gets a kick" out of teaching a graduate evening course in chemical engineering economics. On the other hand, quite some time ago, Cziner, a member of R. S. Aries & Associates, recognized that the chemical business needs not only chemists or businessmen, but people trained in both arts. As a result, with a Ch. E. degree in his pocket, Cziner took time off from work to obtain an M.B.A. from Columbia University.

Engineering training had taught him that academic work provides only fundamentals. With this in mind, he worked with the Department of Commerce, ACS, the Bureau of Labor Statistics and in Wall Street in such varied fields as finance, statistics, labor analysis, market research, and sales and distribution.

Aries finds his relaxation in foreign travel, taking his family to beach resorts in far away countries. Cziner leans to music and American history for his relaxation, having libraries on both.

Standard Indiana Names New Research Group Leader

Thomas M. Moore, promoted to group leader at the Whiting, Ind., research laboratories of Standard Oil Company (Indiana), joined Standard in 1946 as a chemical engineer. A native of Evansville, Ind., he was graduated from Illinois Institute of Technology.

Nutter, Panoma Gas Plant "Like That"

When I. Earl Nutter wrote "Panoma Gasoline Plant Favors Intermediate Separation Over Consecutive Topping" on page 146, he knew his subject inside and out. For the process design of the Panoma Corporation's plant at Hooker, Okla., was basically developed by Nutter, a 1924 graduate of Oklahoma A & M. After his graduation, he spent some time with Phillips Petroleum Company as plant chemist at Shidler, Okla., and later in the original organization of the liquidified petroleum gas and, then the research departments. Successive promotions made him chief technologist and assistant superintendent of the Texas Panhandle Division of Phillips natural gasoline department at Borger, Texas. In 1937, Nutter joined the firm of Hagy, Harrington & Marsh, which later was to become the Panoma Corporation. He is a member of API and IPAA.

Fred Boynton Worked His Way To The Top

Texas-born Fred B. Boynton, author of "Producing 90-Octane Gasoline With Houdriflow" on page 133, is a man who started at the bottom and worked his way up in the oil industry. He graduated from the University of Oklahoma in 1935 with a B. S. degree in mechanical engineering and immediately went to work for Tide Water Associated Oil Company at its Drumright plant, starting a sa laborer, and working his way up as gauger, pumper, special projects engineer and member of the engineering staff. With the completion of Tide Water's Houdriflow catalytic cracking unit in 1950, he was made operating foreman. Boynton married in 1932 and has one daughter. When he isn't spending his off hours doing church work, his time goes for his hobbies, woodworking and "tinkering." He is also a member of the local Lions Club.

Fred Boynton

Corrosion Engineers Reveal Techniques

In "What Can Be Done To Combat Corrosion Of Refinery Tank Roofs?" on page 124, H. F. McConomy and J. J. Hur reveal some of the thinking and techniques that have made them valuable members of Atlantic Refining Company's corrosion engineering staff. Both men have their offices in Philadelphia, and McConomy is currently supervisor of chemical engineering design in Atlantic's research and development section. He has been working in the chemical engineering and corrosion engineering fields since joining the company in 1943, the year he graduated from Pennsylvania State College with a B. S. degree. During World War II, he was loaned to the U. S. government to apply Atlantic's anti-corrosion techniques to the "Little Big Inch" pipe line. In 1951 he was chairman of the National Association of Corrosion Engineers.

J. J. Hur is a member of the engineering design section in Atlantic's research and development department and is leader of the materials and corrosion engineering group. He is a graduate of Ohio State University, having received his B. Ch. E. in 1942 and his M. Sc., in 1947 while in the interim serving in the U. S. Naval Reserve. Since 1947, he has been doing chemical engineering and research activities. He is a member of the National Association of Corrosion Engineers.

C. B. Truitt Made Member Of Hiwan Petroleum Company

C. B. Truitt has been made a member of Hiwan Petroleum Company of Houston as vice president and manager of sales.

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CONDENSER AND HEAT EXCHANGER TUBE EDITION

COPPER ALLOY BULLETIN

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PHYSICAL PROPERTIES OF DURONZE IV— Arsenical Aluminum Bronze Tubes

Each alloy possesses special physical and chemical properties which makes it ideal for certain conditions. However, since circulating water is subject to continual changes in composition, temperature, velocity, debris, sediment and biofouling, it is difficult to state in advance which alloy will give the maximum service life. Fortunately, considerable data has accumulated with time which gives us a greater insight on the behavior of alloys and their resistance to corrosion.

Fresh Water Conditions

Duronze IV (95% copper, 5% aluminum, and approximately 0.25% arsenic) shows good to excellent resistance to a wide variety of fresh waters. Field tests conducted in Lake Erie showed corrosion rates of a very low order. It is not susceptible to "coppering", a type of attack sometimes encountered in high-zinc brasses where it is known as dezincification. In fresh water polluted with paper mill wastes, Duronze IV showed superior corrosion resistance over the standard copper-base condenser tube alloys. However, in the presence of debris, localized corrosion may occur.

Brine and Sea Water

Duronze IV shows good to excellent corrosion resistance to brines. It is not recommended for use in brines containing a high concentration of sulfides but stands up well when the sulfide content is low.

Duronze IV gives good to excellent performance in sea water depending upon the nature and extent of contamination by industrial refuse and sewage.

Effect of Arsenic

In tests at Kure Beach, North Carolina, conducted in clean, flowing sea water, Duronze IV (arsenical aluminum bronze) proved twice as corrosion-resistant as aluminum bronze without arsenic.

Extensive air-impingement corrosion tests conducted in salt water contaminated by sewage resulted in deep, rapid, localized corrosion pitting in non-arsenical aluminum bronze. Localized pitting, sometimes called pin-hole attack, is characterized by the formation of narrow pits which rapidly deepen and eventually pierce the tube wall. In contrast with the pits formed by air impingement, the inside surface of these pits is dark and discolored, even scaly. The addition of a small percentage of arsenic to this alloy not only renders it more resistant to air-impingement type of corrosion but improves its resistance to pitting.

Biofouling Retarded

Due to its high corrosion resistance, Duronze IV is susceptible to fouling by marine organisms. The living organisms may obstruct the flow and affect the heat transfer rate. They cause no difficulty as far as corrosion is concerned. However, dead organisms, particularly barnacles, when allowed to remain attached to the surface of the metal, often lead to pitting.

This is explained by the fact that Duronze IV has a low rate of solubility in sea water. It therefore does not introduce to the water film adjacent to its surface enough copper salts to be toxic to marine organisms.

Under conditions where biofouling is severe such as in warm, clean sea water, care should be taken to keep the Duronze IV tubes as clean as possible. The water velocity should be high enough (continuous at 6 feet per second or higher) to prevent marine organisms from attaching themselves to the metal surface. Chlorination should be sufficient to discourage biofouling. Dead marine organisms, particularly barnacles, should be promptly removed by mechanical means.

Paint sprayed on water boxes and tube sheets and inadvertently inside of condenser tubes has led to intense localized pitting. Therefore, paints should be applied cautiously in order to prevent trouble from this source.

Chlorinated Sea Water

Duronze IV is generally more resistant to chlorinated sea water than other copper-base alloys such as Admiralty, aluminum brass and cupro nickel.

In common with other copper-base alloys, Duronze IV shows excellent corrosion resistance to steam and steam condensate. However, steam condensate contaminated with much ammonia may lead to stress-corrosion cracking. Duronze IV is not recommended for service involving the handling of high concentrations of ammonia. Under such conditions Duplex Tubing with steel to the ammonia side and a copper-base alloy to the water or brine side is very satisfactory.

PHYSICAL AND MECHANICAL PROPERTIES—ALUMINUM BRONZE 53

ANALYSIS	
Copper	94.25
Aluminum	5.5
Arsenic	0.25
MECHANICAL PROPERTIES	
Tensile Strength—Soft	50,000
Yield Strength—Soft	20,000
Elongation % in 2" Soft	53
Contraction in Area % Soft	70
Rockwell Hardness—Soft	F78
Elastic Limit—Soft	10,000
Modulus of Elasticity in Tension x 10^6	17.5
PHYSICAL CONSTANTS	
Density @ 68° F lbs./cu. in.	.295
Specific Gravity	8.16
Melting Pt. °F Liquidus	1945
Solidus	1920
THERMAL CONSTANTS	
Coefficients of Thermal Exp. per °F from 68°F to 572°F x 10^{-6}	10.0
per C° from 20°C to 300°C x 10^{-6}	18.0
Thermal Conductivity at 68°F BTU/sq. ft./ft./hr./°F	46
Calories/cm^2/cm/sec/°C	0.19
Thermal Capacity (spec. heat) @ 68°F BTU/lb./°F	.09
@ 20°C cal./gm./°C	.09
ELECTRICAL CONSTANTS	
Resistivity ohms/mil foot @ 68°F (annealed)	60
Conductivity % IACS @ 68°F (annealed)	17
(annealed) megohm-cm^3 @ 20°C	0.099
Resistivity, micro-ohm centimeters @ 20°C (annealed)	10
Color	Pink Silver
FABRICATION PROPERTIES	
Cold working	Good
Hot working	Good
Hot working Temp. °F	1450-1600
Hot working Temp. °C	800-925
Machinability rating	20
Soft soldering	Good
Silver brazing	Good—special flux
Oxyacetylene welding	Good—coated rods
Carbon arc welding	Good—coated rods
Resistance welding	Fair
Polishing	Good
Annealing Temp. °F	1000-1200
SPECIFICATIONS	
A.S.T.M.	B-111-50
A.S.M.E.	SB-111

(8777)

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ammonium nitrate

sulphuric acid

brine

bleach liquors

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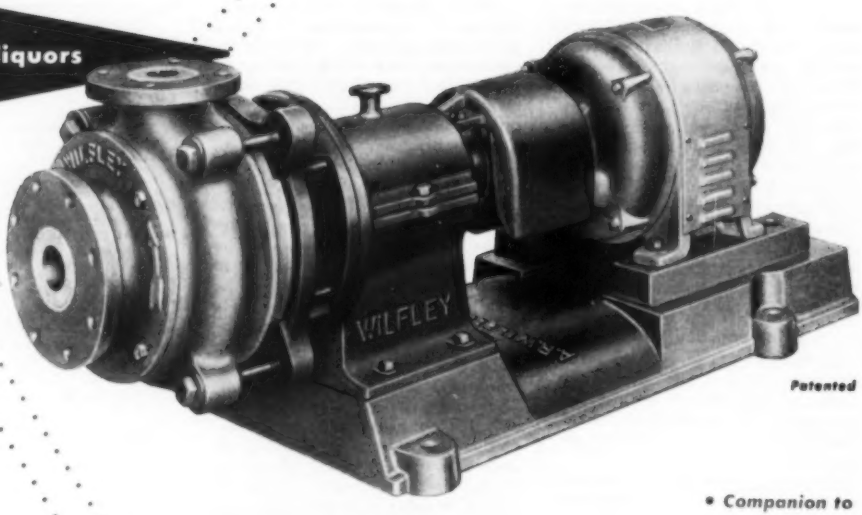

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The MONTH... in the INDUSTRY

Davison Davidson Miller Petersen

$3.5 Billion Materials Aid, 188 Refinery Tax Grants OK'd

Up to March 28, the Petroleum Administration for Defense had approved applications for priorities assistance on materials for construction of 3,573 oil and gas projects having a total value of more than $3.5 billion of which $1,124,677,502 went for refining projects and $265,095,204 for natural gasoline. Through February 25, the Defense Production Administration had approved for rapid tax amortization a total of 188 petroleum refining applications involving a proposed investment of more than $1 billion, with 116 other projects pending at an estimated cost of almost $307 million.

These statistics were revealed in a compilation for all industries released recently by DPA. Of the total oil refining investment, tax write-off was allowed for $618 million, or at a rate of 61.7 percent. In addition to refining projects, a separate classification of natural gasoline facilities expansion listed 39 projects approved calling for an investment of almost $83 million, of which an average of 57.5 percent was certified for tax amortization. Fifty-seven additional projects, calling for an investment of more than $119 million are pending.

In addition to the $3.5 billion materials aid, applications for another 289 projects valued at more than $124 million were either withdrawn by operators or denied by PAD. An additional 282 applications for approval of projects valued at more than $1.1 billion had not been processed as of March 28. PAD's project construction figures do not include allotments of materials made for well drillings.

Fifth Edition API-ASME Code For Liquids, Gases Ready

The Fifth Edition of The API-ASME Code for the Design, Construction, Inspection and Repair of Unfired Pressure Vessels for Petroleum Liquids and Gases is now available, the American Petroleum Institute and American Society of Mechanical Engineers have announced. Among the changes from previous editions are more accurate shell and head design formulas, the details for minimum welding required around opening attachments, acceptance criteria for pressure-relief devices, and information pertaining to the proving of materials not completely identified. Copies of the new edition are available through the American Society of Mechanical Engineers.

Legatski Wins Hanlon Award At 31st Annual NGAA Meeting

Meeting in Houston for the first time in its 31-year history, the Annual Convention of the Natural Gasoline Association of America was attended by over 1500 delegates, April 30-May 2. The meeting featured nine technical forums and the presentation of the Hanlon Award.

The forums at which technical papers were presented included sessions on corrosion, extraction and separation calculations, gathering systems, traffic, safety and personnel, fractional analysis, operations and liquefied petroleum gas. The final session was devoted to a "Quiz on Operations" in which executives and operating men put their questions to a panel of experts on processing, production, and operating trends.

Addressing the general session of the association, Hines H. Baker, president, Humble Oil & Refining Company, spoke on "Our Greatest Asset." Also on the program were Guy C. Kiddoo, vice president, First National Bank of Chicago, who spoke on "Natural Gasoline Money, Credit and Profits," and the Honorable Sumner Pike, member of the Atomic Energy Commission, on "Atomic Energy."

At the business session, John F. Lynch of Corpus Christi, Texas, president of the La Gloria Corporation, was reelected president of the association. All other officers also were reelected. They are Z. C. Ambrose of the Southwest Gas Producing Company, Monroe, La., R. W. Heath of the Signal Oil & Gas Company, Long Beach, Calif., F. M. Perry of the Cities Service Oil Company, Bartlesville, Okla., and Albert H. Weil of the United Gas Pipe Line Company, Shreveport, La., vice president, and William F. Lowe of Tulsa, secretary-treasurer.

The Hanlon award, highest honor in the natural gasoline industry and one of the ranking awards of the entire petroleum field, was conferred on Theodore William Legatski, assistant director of research, Phillips Petroleum Company, Bartlesville, Okla.

Legatski

Legatski is the sixteenth Hanlon award winner, and the fourth member of the Phillips organization to be so honored. The donor is E. I. Hanlon, National Bank of Tulsa.

The official presentation of the award cited Legatski "For his over 25 years of productive research effort and guidance in the field of the light hydrocarbons, the results of which have served to strengthen and extend the outlets for the products of the natural gasoline industry; for his many contributions to the better understanding of the relationships existing between fuel composition and engine behavior; for his contributions in the field of aviation gasoline manufacture which so greatly increased our productivity in wartime; for his valuable services as a technical liaison between the petroleum industry as a whole and the automotive industry; and for his abiding faith in the future of the natural gasoline industry."

California Standard Wins Accident Prevention Awards

The American Petroleum Institute has presented 11 Accident Prevention Certificate Awards to Standard Oil Company of California in recognition of 10,500,000 man-hours worked by employees without a disabling injury. **(See photo above.)**

Acting on behalf of the API, T. S. Petersen, president of the company, recently presented the certificates to G. A. Davidson and Gage Lund, vice presidents under whose jurisdiction the safety records were achieved. Left to right in the photo above are W. W. Davidson and G. A. Davidson, vice presidents; O. N. Miller, manufacturing department manager; and Petersen.

Nine million-hour certificates were awarded to units of the company's Richmond refinery, one million-hour certificate to the El Segundo refinery and one 500,000-hour certificate to the East Coalinga production division of the Producing department.

DPA Expansion Goal Set for Ethylene Glycol Production

The Defense Production Administration has announced expansion goals for production of ethylene glycol, ethylene oxide and carbon black. Expansion goal for ethylene glycol, which is used in producing "permanent" type antifreeze, is 850 million pounds production capacity by January 1, 1955. This would be an increase of 327 million pounds over January 1, 1951 capacity. Expansion goal for ethylene oxide is a capacity of 969 million pounds by the same date, which will mean an increase of 423 million pounds over January 1, 1951 production. The carbon black expansion goal has been set at 2.3 billion pounds over the January, 1951 capacity of 800

The Month...

million pounds. DPA said it has sufficient applications for rapid tax amortization on hand now to meet expansion requirements for ethylene glycol and ethylene oxide, but that applications on carbon black expansion are still about 250 million pounds short of the goal.

Reconstituted API LP-Gas Group Headed by G. R. Benz

The American Petroleum Institute's Committee on Liquefied Petroleum Gas has been reconstituted with George R. Benz, Phillips Petroleum Company, appointed chairman, and E. O. Mattocks of API, New York, as secretary. The new committee will undertake development of standards for LP-Gas installations at marine and pipe line terminals, natural gasoline plants, refineries and tank farms.

Pritchard Made Chairman Of McColl-Frontenac Board

J. M. Pritchard, former president of McColl-Frontenac Oil Company, Ltd. has been elected chairman of the board to succeed A. A. Magee who assumes the new position of chairman of the executive committee. T. C. Twyman has been named president and executive officer with G. R. Taylor succeeding him as executive vice president. A. G. Farquharson was elected vice president in charge of refining, and T. V. Anderson former treasurer and comptroller, was made vice president and treasurer.

Chemical Industry Finds New Use for Natural Gas

For the first time in industry, the partial oxidation of natural gas with oxygen will soon be used as the basic process in the production of anhydrous ammonia. The new process will be employed at the $15-million plant of the Spencer Chemical Company, now under construction at Vicksburg, Miss. The plant will produce 200 tons of gaseous ammonia daily for use as fertilizer. Contracts have been awarded to Air Products, Inc., to design, manufacture and install key equipment, at a cost of more than $1 million, which will extract 180 tons of oxygen and 310 tons of nitrogen per day from the air. The oxygen is combined with natural gas; then hydrogen, one of the products of this reaction, is added directly to the nitrogen produced by the Air Products unit to form ammonia.

Oil Industry Wages, Hours Covered In BLS Statistics

Straight-time earnings in October-November 1951 averaged more than two dollars an hour for workers in 60 percent of petroleum refinery occupations studied by the U. S. Labor Department's Bureau of Labor Statistics, a recent report of the Bureau shows. The report pointed out that stillmen had the highest average earnings: combination units, $2.39; cracking (catalytic), $2.43; cracking (other than catalytic), $2.32; and straight-run, $2.33. Earnings of assistant stillmen on various types of units averaged from 16 to 24 cents below averages for corresponding types of stillmen, the BLS said. Among the 14 jobs for which average earnings could be presented in all seven major economic regions, differences between highest and lowest regional averages varied from 15 cents for laborers to 32 cents for stillmen, cracking (other than catalytic). The Bureau said the refining study excluded premium pay for overtime or night work. It estimated that the study covered about 147,000 employes in refineries employing 51 or more workers.

April Du Pont Survey Shows Slight Decrease in Octanes

Premium gasoline octanes averaging 90 Research or more were reported for 27 out of 49 cities in the United States and Canada in an April 1952 survey conducted by the Du Pont Company. This compared with 28 out of 49 in an April 1951 survey. Regular gasoline octanes averaged 85 Research in 13 out of 49 cities in April compared with 12 out of 49 in January, and 16 out of 48 in the April 1951 survey.

Delivers Commencement Talk

David W. Harris, president and director of Universal Oil Products Company will deliver the address at the Sixty-Ninth Commencement exercises of Georgia Institute of Technology in June, school officials have announced. Harris is the son of a former governor of the State of Georgia and founder of Georgia Tech.

Leach Named President of Texaco Succeeding Klein

The Texas Company board of directors has elected Colonel Harry T. Klein

Leach

Klein

as chairman of the executive committee, a newly-created position. Executive vice president J. Sayles Leach was elected president of the company to succeed Colonel Klein. Klein entered the service of The Texas Company in 1921 as assistant general counsel and in 1944 was elected president of the company. J. Sayles Leach joined the Texas Company in 1916 as a bookkeeper in the Dallas sales office. By 1925, he had advanced to the post of superintendent of sales of the Dallas district. In 1949 he was elected a director of the company and in 1950, was named executive vice president. Both Klein and Leach will continue to serve on as directors of the company.

Frame Leaves PAD After 18 Months, Named To CS Post

A. P. Frame, who has just returned to Cities Service after 18 months on loan to PAD, has been elected first vice president of Cities Service Petroleum, Inc., co-ordinating company for petroleum operations of the CS organization. He is also president of Cities Service Research & Development Company and vice president of Cities Service Refining Corporation and Cit-Con Oil Corporation. Frame drew praise from Secretary of the Interior Chapman upon his departure. He joined PAD in 1950 to direct organization of the agency's first emergency activities, aviation fuels, and served as assistant deputy in charge of domestic industry operations from February 1952 until assuming an associate deputy post in March.

Stepping into Frame's vacated post is associate deputy PAD's J. Ed Warren, who is slated to replace Bruce K. Brown as deputy administrator on June 1.

Chapman Calls For Commercial Synthetic Fuels Production

Secretary of the Interior Chapman has declared that "the time is now at hand when we must begin to move into commercial production of synthetic fuels." In the 1951 annual report released recently, Chapman also said that tests of "known areas of Wyoming may boost the estimate of shale oil reserves to one trillion barrels. After recounting the need for conservation of petroleum reserves in view of the ever-mounting demand, Chapman said that "in this connection, the development of synthetic liquid fuels offers a great opportunity.

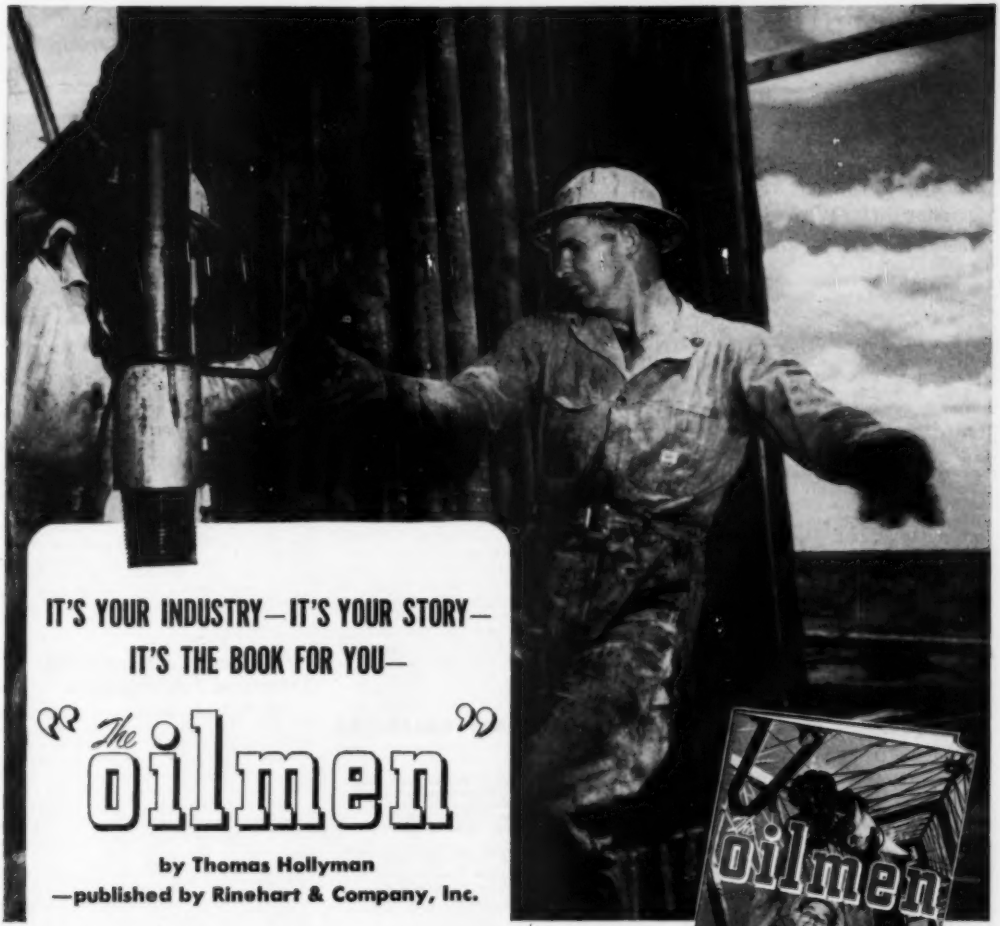
"It is now possible to increase oil refining capacity over night, and by the same token it takes time to build synthetic liquid fuel plants," he added. "It

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1951:									
January 27	6,066	6,483	244,230	21,106	134,628	9,954	63,324	9,905	41,337
February 24	5,954	6,524	237,204	20,815	145,824	10,545	52,590	9,471	39,881
March 31	6,041	6,381	235,956	20,398	150,601	9,365	46,932	9,147	38,578
April 28	6,154	6,236	242,479	19,876	145,987	8,061	47,852	8,747	36,991
May 26	6,163	6,430	246,400	21,102	139,863	8,580	55,120	9,045	38,092
June 30	6,181	6,595	247,299	21,666	136,355	8,542	70,001	9,036	42,046
July 28	6,205	6,396	251,203	21,539	130,518	8,174	81,662	8,858	45,887
August 25	6,220	6,569	252,257	21,592	125,590	8,761	91,692	8,763	47,906
September 29	6,303	6,558	255,519	21,085	122,468	9,124	104,170	8,332	49,014
October 27	6,340	6,461	259,852	22,364	121,069	9,380	109,095	8,433	50,412
November 24	6,232	6,757	260,465	22,181	122,105	9,428	105,693	9,305	48,704
December 29	6,204	6,763	256,437	22,478	133,070	10,522	89,744	9,371	43,751
1952:									
January 26	6,194	6,384	253,186	21,649	143,621	10,391	71,922	9,222	39,957
February 23	6,366	6,569	255,184	21,528	150,900	10,552	59,573	9,024	38,484
March 29	6,402	6,590	256,661	21,837	158,816	9,712	48,337	8,846	36,565
April 26	6,371	6,600	264,781	20,903	155,367	9,236	51,274	9,034	38,526



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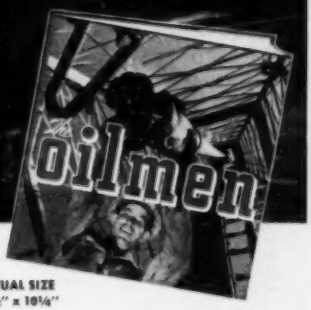

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The Month...

is now highly desirable that commercial synthetic fuels plants be started to bridge the gap between industry and the research and demonstration plant work already done by the Bureau of Mines."

Ebasco, BM Synthetic Fuels Statistics Differ With NPC

The Bureau of Mines released today a report from Ebasco Services, Inc., which generally supports the bureau's own figures on costs involved in construction and operation of making synthetic liquid fuels through a coal hydrogenation process. Both Ebasco and the Bureau differ sharply on most points from the National Petroleum Council synthetics study group. Although supporting most of the Bureau's data, Ebasco came to the conclusion that it would not be feasible to finance a synthetic plant "with private capital under the conditions prevailing January 1, 1951."

Production costs of total synthetic fuels and chemicals at a hypothetical 30,000 barrel-per-day plant at Rock Springs, Wyo., was found by Ebasco to be 11.4 cents a gallon, compared with the Bureau's finding of 10.2 cents and the NPA determination of 18.4 cents. Ebasco estimated the project would involve a capital investment of $403,827,000, the Bureau of Mines said $414,440,000, and the NPC figured $532,900,000.

Interior Secretary Chapman said he was "highly pleased" with the audit made by Ebasco on the Bureau of Mines data, adding the Ebasco report "gives us good guidance and help" in continuing government development of a synthetic fuels process. He indicated that the bureau does not interpret the report as a go-ahead in support of any particular coal hydrogenation project, although the agency still is reviewing "informal" applications of E. Eberstadt and Company. Chapman stressed the point that, although the Defense Production Authority has been asked to set aside $100 million for possible underwriting of a private, commercial-sized synthetics plant, such funds would not be reserved for any particular project nor for any special process.

A bureau synthetics expert has said that the Eberstadt proposal is "tentative" but that the company "presumably" is working up "a more firm proposal" for submission. The plant would involve a 30,000-barrel-per-day coal hydrogenation plant (probably in Illinois) to be built at an investment of about $400 million, with the government signing purchase contracts, granting load or offering some other type of assistance.

Kemp Sees Chance for Shale Oil, Not Hydrogenation

L. C. Kemp, Jr., director of research for The Texas Company, took a dim view of the Bureau of Mines' efforts to justify the erection of coal hydrogenation plants for the production of synthetic liquid fuels recently in an address before the National Petroleum Association. In a comprehensive report on various methods of producing synthetic liquid fuels, Kemp said oil shale offered the greatest possibilities, and he thought its potentialities should be subject to a continued study. Commercial retorting of shale for the recovery of oil in a number of foreign countries has not been self sustaining, Kemp said, and many such projects have been abandoned. However, gasoline costs indicated in the National Petroleum Council report of 16.2 and 14.7 cents respectively for single and multiplant operations indicates that further consideration must be given to the desirability of establishing commercial operations for the production of shale oil. Had the shale deposits occurred nearer major consuming areas or if quality of crude shale oil were better, it is likely there would already be considerable activity in commercial exploitation of the material, he added.

IPAA Sees Demand for All Oils 4.4 Percent Higher

The Independent Petroleum Association of America has estimated that the total demand on the United States for all oils will average 7,797,000 barrels daily this year, 4.4 percent greater than in 1951. IPAA's Supply and Demand Committee calculated domestic demand would increase 5.9 percent to 7,460,000 barrels per day while exports would decline to 337,000 barrels daily or 20.5 percent. It placed total required supply to meet demand and inventory changes at 7,884,000 barrels per day in the first quarter, 7,791,000 during the current quarter, 7,765,000 barrels daily in the third quarter, and 7,942,000 in the last quarter.

THE OIL MAN'S CALENDAR

MAY 11–14	AIChE, Regional, French Lick, Ind., French Lick Springs Hotel.
12–15	API, Div. of Ref. Midyear, San Francisco, St. Francis Hotel.
12–14	LPGA, Annual, Chicago, Palmer House.
26–28	AGA, Production and Chemical Conf., New York, Hotel New Yorker.
27–29	Southwestern Gas Measurement Short Course, U. of Okla., Norman.
JUNE 2– 4	Instrumentation for the Process Industries Symposium, Engineering, Chemical Engineering Departments, A & M College, College Station, Texas.
23–27	ASTM Annual, Exhibit of Testing Apparatus and Laboratory Supplies, New York, Hotels Statler; New Yorker.
SEPT. 8–12	ISA Conference and Exhibit, Cleveland, Cleveland Auditorium.
10–12	National Petroleum Assn., Annual, Atlantic City, The Traymore.
14–19	ACS, National (Petroleum Division), Atlantic City, The Traymore Hotel.
OCT. 1– 3	South Central Region, National Assn. Corrosion Engineers, New Orleans, La., Jung Hotel.
9–10	California Natural Gasoline Assn., Annual, Los Angeles, The Ambassador.
20–24	National Safety Council, National Safety Congress and Exposition, Chicago, Conrad Hilton Hotel.
Wk. of Oct. 27	AGA Annual, Atlantic City, Auditorium.
NOV. 10–13	API Annual, Chicago, Conrad Hilton Hotel and Palmer House.
DEC. 7–10	AIChE, Annual, Cleveland, Hotels Cleveland and Carter.

Dr. Eugene Schoch Elected To AIChE Life Membership

As a tribute to his numerous contributions to chemical engineering education, research and the AIChE, Dr. Eugene Paul Schoch, professor of chemical engineering and Director of the Bureau of Industrial Chemistry at the University of Texas, has been elected to life membership in the South Texas Section, American Institute of Chemical Engineers. A member of the Institute since 1925, Dr. Schoch has long been known as the "Daddy of Chemical Engineering in the Southwest." He is the first member of the South Texas section to receive the lifetime membership award. One of his first contributions to the profession was the initiation of a course in chemical engineering at the University of Texas in 1916. Schoch's major efforts in the past two decades have been devoted to the conversion of natural gas to a chemically more usable form of hydrocarbon. His work has culminated in a commercially feasible method of producing acetylene from natural gas, the Schoch Acetylene process.

Schoch

NPC Hears of European Oil Expansion, Fuel Problems

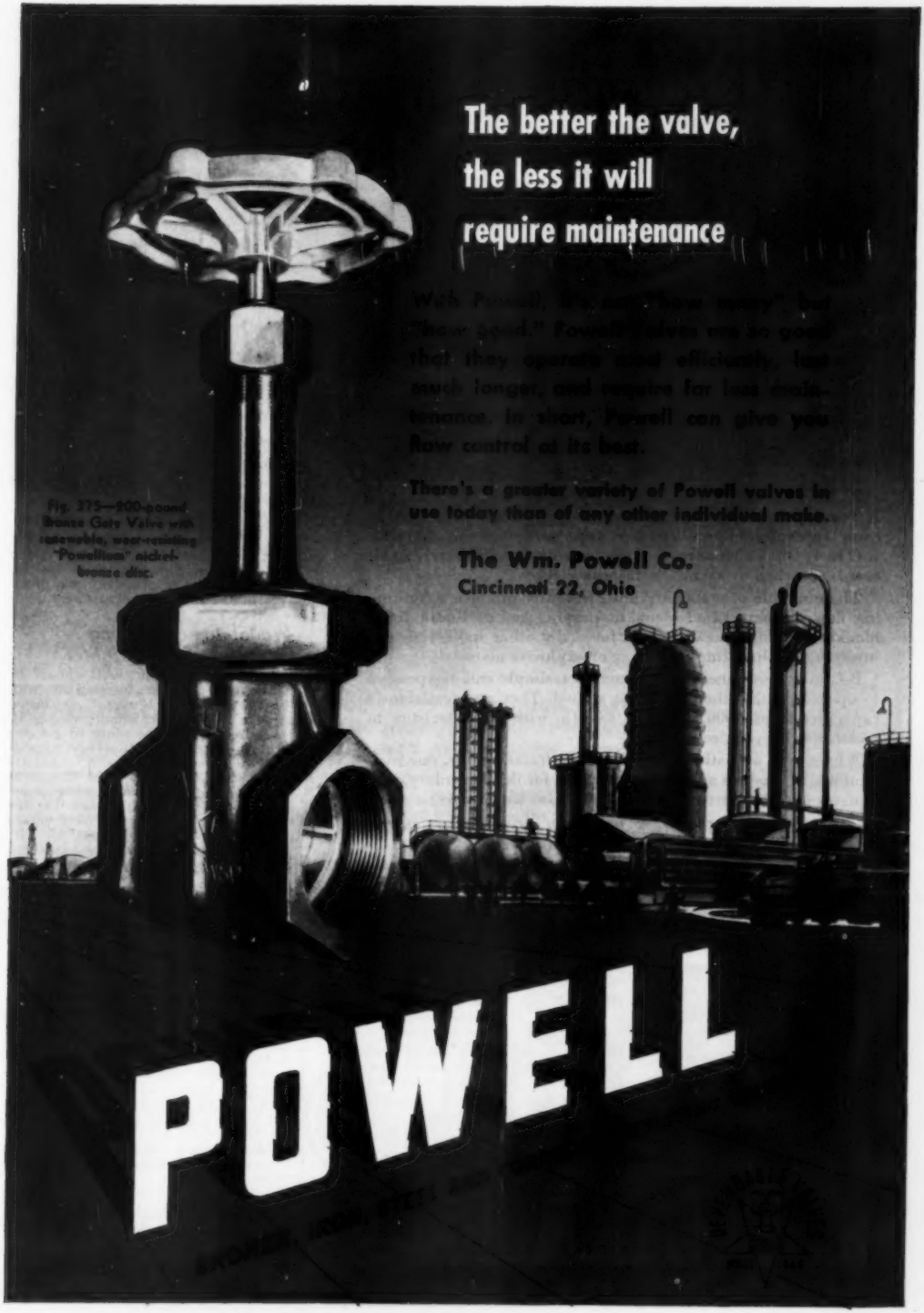
The current estimate for European refining capacity when the expansion program is complete, in 1954 or thereabouts, is about 1.7 million barrels per day, an increase of nearly six times 1947 capacity, Cornelius J. Dwyer, chief of Petroleum and Petroleum Equipment Branch of the Mutual Security Agency told a National Petroleum Council group recently. Dwyer said the Mutual Security Agency considers one of its most important current responsibilities to assist in channeling increased European output into those areas where it is most needed. He added that Europe's chronic coal shortage, which has necessitated shipment of U. S. coal to Europe, raises a question as to whether more emphasis should not be placed on increased use of fuel oil to replace coal use.

Standard Oil of New Jersey Sells Attapulgus Interests

Standard Oil Company (New Jersey) has sold its half interest in the Attapulgus Clay Company for an undisclosed sale price. Attapulgus produces Fuller's earth products for F. Eberstadt & Company, Inc., and Lazard Freres & Company. The remaining 50 percent interest is owned by The Atlantic Refining Company.

Hoge, Ardern Will Head Houdry Process Departments

Houdry Process Corporation has announced that A. Wesley Hoge will be in charge of process design and David B. Ardern will be in charge of technical service. Hoge joined Houdry in 1943, and his activities have included supervision of the initial operation of newly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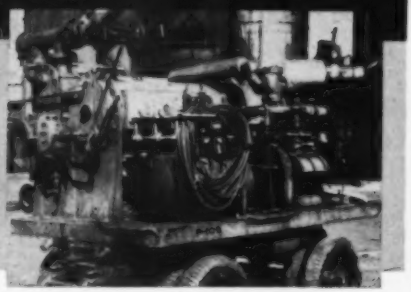

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If your operations involve materials or processes which might cause an explosion-produced fire, you can reduce the risk with R-C Inert Gas Generators. In many instances, the relatively small cost is absorbed by savings in insurance costs.

These mobile or stationary units instantly produce a continuing flow of inert gas, for use in purging gas or liquid lines, blanketing dangerous areas and for many other industrial uses involving the handling or storage of explosive materials.

R-C Inert Gas Generators are compact, simple and inexpensive to operate, with either oil or gas as fuel. They are available in capacities from 1,000 cfh to 50,000 cfh, with characteristics to match specific requirements.

Where even a relatively low explosion hazard exists, one incident might produce a disastrous fire. Ask for details on how such dangers may be averted with R-C Inert Gas Generators.

ROOTS-CONNERSVILLE BLOWER CORPORATION
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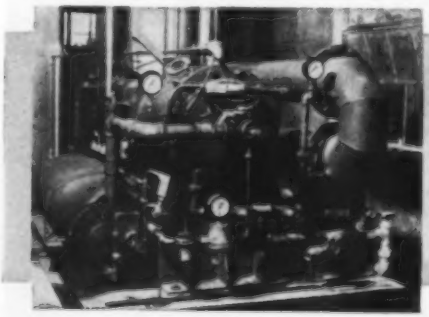


Installation of three R-C Inert Gas Generators similar to this one helped one large plant save $6,000 per month insurance premiums, as well as substantially reduce danger of production losses caused by explosion or fires. Capacity of each unit, 6,000 cfh.

Reg. U. S. Pat. Off.

ROOTS-CONNERSVILLE
BLOWER BUILDERS SINCE 1854
ONE OF THE DRESSER INDUSTRIES

The Month...

licensed commercial units and the continuous plant surveys of the Houdry organization. Ardern joined Houdry in 1942 and has been primarily engaged in process design, concentrating on the commercial design of moving bed catalytic cracking units and more recent units for catalytic reforming of petroleum naphthas to aromatics and high octane gasolines.

Veenstra Appointed Asiatic Petroleum Vice President

Sybrand J. Veenstra has been appointed a vice president of Asiatic Petroleum Corporation by the board of directors. Veenstra entered the employ of Bataafsche Petroleum Maatschappij at The Hague in 1928, having graduated as a mechanical engineer at the University of Delft, Holland. From 1930 to 1939, he was assigned to a variety of technical jobs in The Hague and at various refineries and oilfields in Indonesia, Venezuela and Curacao. In September of 1939 he joined the Asiatic staff and prior to his appointment as vice president, was manager of the materials department.

Veenstra

Availability of Refining Equipment Looks Brighter

Supplies of "B" products should be more than sufficient to keep up with the oil industry's 18-month expansion program with some definite easing already being felt, according to government materials experts. They emphasized, however, that most "B" items are still tight, particularly such things as large motors, boilers and switch gears. The officials also pointed out that the refining industry seems to have passed the stage in which demand for "B" products suddenly swelled as basic construction on many projects was completed about the same time and equipment was needed for installation.

Abadan Shutdown Leaves Some 2000 Employees Jobless

Some 2000 employees of Anglo-Iranian have lost their jobs as a result of the enforced shutdown of the oil company's Abadan refinery with the balance of the personnel from Iran, approximately 600, either joining the company's United Kingdom staff or placed in a reserve for various other planned projects of the company. More than 1000 of those released by the company have applied for help from a special re-settlement panel set up by the company.

These figures were released recently through the Anglo-Iranian Information office.

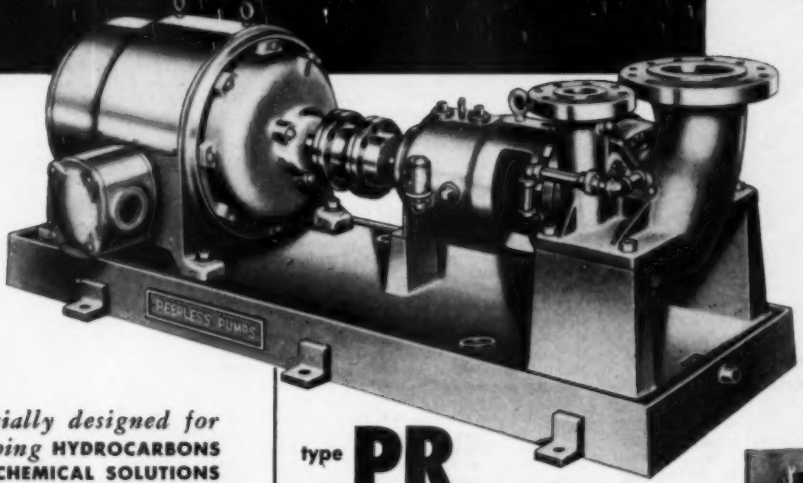
Petroleum Industry's Injury Frequency Rate Up in 1951

The oil industry had an injury frequency rate (number of disabling injuries per one million hours worked) of 10.50 in 1951, compared with 10.08 in

PEERLESS TYPE PR

A CENTER-LINE-MOUNT PUMP FOR HEAVY DUTY PROCESS SERVICE IN REFINERIES AND CHEMICAL PLANTS

Peerless BUILDS **DEPENDABLE PUMPS**



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CAPACITIES	Up to 1000 gpm
OPERATING HEADS	Up to 625 feet
TEMPERATURES	Up to 850° F.
CASE PRESSURES	Up to 600 psi
DRIVES	Horizontal electric motor is standard; others as required, such as steam turbine drive or stationary engine drive.
MATERIALS OF CONSTRUCTION	Liquid end can be furnished in cast iron, bronze, carbon steel, stainless steel or other materials as required for the intended service.
LIQUIDS HANDLED	Hot oil, propane, butane and all petroleum hydrocarbons, process liquids.
NPSH CHARACTERISTICS	Designed to operate with minimum available NPSH.

type **PR**

FOR THOSE TOUGH HIGH-TEMPERATURE AND HIGH-PRESSURE APPLICATIONS IN REFINERY AND PROCESS WORK . . .

Maximum interchangeability, extra-heavy wall thicknesses, extra-low NPSH requirements and extra-rigid case-frame construction make the Peerless Type PR pump ideal for those rugged duty refinery pump jobs.

Furnished in a complete range of sizes, a Peerless Type PR will cover nearly all your pump needs. Available in various alloy materials. Adequate water-cooling jackets and water-cooled stuffing box, with mechanical seal optional, and heavy duty shaft with carefully balanced bearing design are features of the Peerless Type PR construction. Many sizes are available from stock in standard materials.

New Bulletin just off the press

Use coupon for Bulletin No. B-1605 which describes the exacting design and construction features of Peerless Type PR pumps.

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PR

The Month...

1950, according to statistics released recently by American Petroleum Institute's Department of Statistics. The report was based on collective experience of almost 300 oil companies and their subsidiaries, employing 481,926 persons with total exposure of 1,033, 663,000 hours.

Parsons Company Announces Appointment of Broom as VP

The Ralph M. Parsons Company, engineers and constructors, have announced the association of Harry P. Broom as vice president in charge of its New York office. For the past 12 years Broom has been associated with E. B. Badger & Sons Company and its successor, Stone & Webster Engineering Corporation. He has also served as director of the development laboratory of Houdry Process Corporation on assignment from the Sun Oil Company.

Broom

Cropper Receives Promotion At Standard Laboratories

C. W. Cropper has been promoted to assistant chief chemist of the Standard Oil Company (Indiana) research laboratories at Whiting, Ind. He has been succeeded as group leader at the company's Casper, Wyo., laboratory by H. M. Schauer, formerly chemical engineer at Whiting. Cropper joined Indiana Standard in 1942 and Schauer in 1946.

Blaw-Knox Licensed to Use Sovac Catalytic Processes

The Chemical Plants division of Blaw-Knox Company has been licensed by the Socony-Vacuum Oil Company to use their technical information and processes pertaining to the catalytic reforming of petroleum hydrocarbons. This agreement supplements an earlier license to the Chemical Plants division to design and build catalytic cracking plants using the Socony-Vacuum patented processes.

C. Laurence Warwick, ASTM Executive Secretary, Dies

C. Laurence Warwick, executive secretary, American Society for Testing Materials, and its administrative head since 1919, died suddenly April 23. Warwick had been active in the Society since 1909 when he graduated from the University of Pennsylvania in civil engineering. While he was Instructor and Assistant Professor at the University, he also served as assistant secretary to ASTM with Edgar Marburg, the Society's founder secretary. In 1919, on the death of Dr. Marburg, he was appointed secretary-treasurer and in 1946 became executive secretary. He had made notable contributions to the field of standardization and research in materials and was recognized as an outstanding authority on materials.

Nationwide Bargaining Continues as Strike Issue

Spot shortages, scattered agreements, restrained optimism and new examples of bureaucratic ineptitude offered distracting sideshows at mid-month to the industry's duel with its striking workers over the underlying issue of nationwide bargaining.

Early settlement of the strike which on April 30 froze 30 percent of the nation's refining capacity may have been near, but the view was obscured by a list of unpredictables. These included: 1) O. A. Knight's estimate of the endurance of his labor coalition which he glued together with a 25-cent wage demand; and 2) the whims of our Washington wonderland.

The wage hike figures most frequently talked ranged from 15 to 18 cents, which the union would regard as a signal victory in this major battle of a long campaign in that it would pose an unanswerable argument to those independent unions which have resisted OWIU pleas for a united front.

Meanwhile the Wage Stabilization Board, which earlier flubbed its mediation efforts, re-entered the scrimmage with a plan for an end to the walkout and more talks umpired by the Federal Mediation and Conciliation Service.

(Industry's reaction to this invitation might be gauged from the tenor of talks at the National Petroleum Association at Cleveland last month. Said William Montgomery, industrial relations manager for Socony-Vacuum Oil Company: "We (our company) believe that these things can be settled, that they will be settled, and must be settled by individual bargaining. They cannot be settled before a board in Washington.")

Not to be ignored was the possibility that the steel-singed fingers of Harry Truman might again have to juggle this hot potato. What he could do would be: 1) nothing; or 2) invocation of the Taft-Hartley Act, which he despises.

Estimated Days' Supply of U. S. Refined Products on Hand

	April 26, 1952	Mar. 29, 1952	April 28, 1951
Motor Fuel	41	46	44
Kerosine	74	64	70
Distillate Fuel Oil	50	46	50
Residual Fuel Oil	26	24	25

(Bureau of Mines' forecast of demand for second and third quarters, 1952, was applied to API's April 26, 1952 stock figures to compute days' supply as of that date. Second quarter demand forecast only was used with API's stocks of March 29, 1952, for data as of that time. Bureau of Mines' actual demand for second and third quarters was used with API's stocks for last year's computations.)

Miller Named to High RFC Synthetic Rubber Position

J. Ernest Miller, plant manager of the Reconstruction Finance Corporation's synthetic rubber plant at Port Neches, Texas, since 1945, has been appointed assistant to the chief of the RFC synthetic rubber division in Washington. Miller is on leave from the B. F. Goodrich Chemical Company while working with the government.

Phillips Announces Several Recent Personnel Changes

Phillips Petroleum Company has announced several recent personel changes. Because of the necessity for expediting the company's numerous applications before the Petroleum Administration for Defense, National Production Authority and other governmental agencies, R. C. Jopling, vice president, will represent Phillips in Washington, D. C., relinquishing his post as advertising head to F. L. Rice. O. E. Bettis will continue as advertising manager. Myron O. Johnson has been named manager of the new coordination and supply department with John L. Kyser as assistant manager. E. H. Lyon is the new assistant sales manager with John Getgood, formerly assistant division manager in the Chicago division replacing him.

W. E. Green, Oil Journalist, Dies At West Coast Home

W. E. Green, 72, for many years active in the field of petroleum journalism in both Texas and California, died of a stroke April 22 at Baldwin Park, Calif. At the time of his death, he apparently was on the road to recovery from a minor stroke suffered several weeks earlier.

Born in Mississippi, Green first started his own weekly newspaper in 1904 in Bay City, Texas. Later selling this paper, he subsequently worked on newspapers in several Texas cities, among them, Beaumont, El Paso, Fort Worth and Houston. He later joined the staff of *The Oil Weekly* (now World Oil) in Houston and, in 1923 moved to California as West Coast advertising and editorial representative of the magazine. In March, 1948, he started his own publication, The Green Sheet, a bi-weekly service devoted to the activity of drilling contractors in California. Death came while he still was publishing The Green Sheet.

So-Vac Licenses German Bead Catalyst Program

A bead catalyst plant similar to Socony-Vacuum's plant at Paulsboro, N.J., will be installed by Kali-Chemie Company at their Nienberg, Germany, refinery. The catalyst plant has been licensed by Socony-Vacuum.

Menzies Heading PAD Unit

John W. Menzies of the Fluor Corporation has replaced Rolland P. Wood, Pure Oil Company, as chief of PAD's Industrial Equipment Branch, Materials Division.

Demands for Jet Fuels Can Be Met, T. L. Apjohn Says

The development of reciprocating aircraft engines and high octane number fuels is practically at an end, but there is plenty of room for advancement in both turbo-jet and rocket-powered aircraft fields, Thomas L. Apjohn of Socony-Vacuum Oil Company said recently in a talk prepared for the Aero Club of New England. He said, touching on the present production of avgas, that plant rehabilitation and new construction are now rolling, and supplies should probably be adequate for all currently

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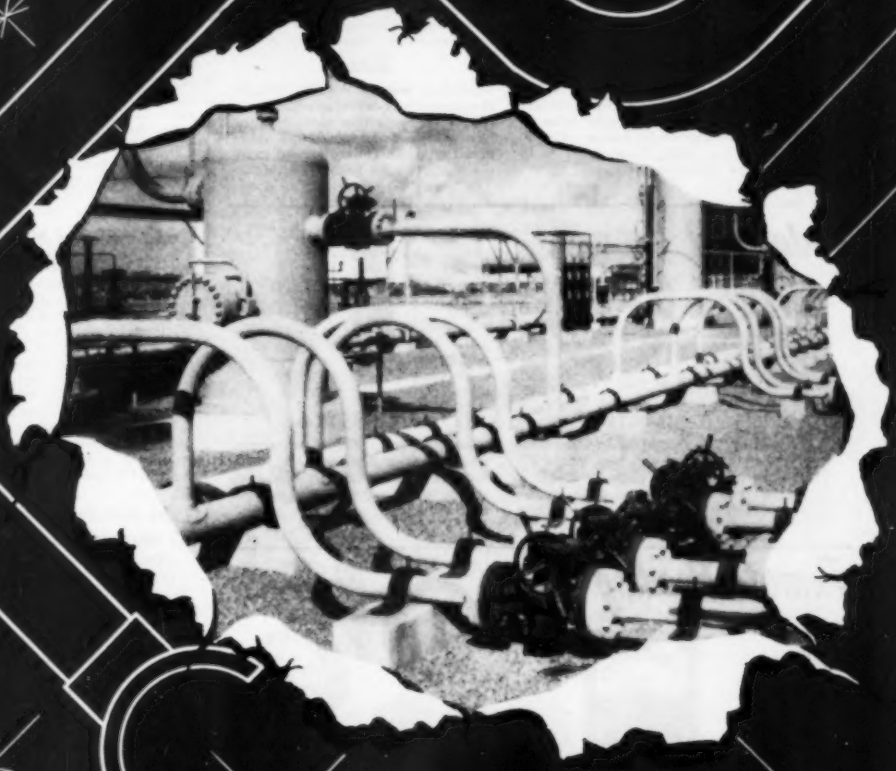

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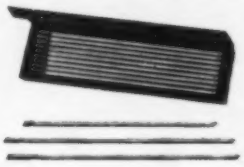

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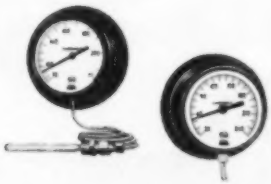

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9413

The Month...

known demands by the fourth quarter of 1952 to relieve the "touch and go" situation prevailing since September, 1950.

He said military requirements for jet fuels under mobilization conditions can be met without disruption of normal civilian demands, while all-out war needs can be filled by acceptable civilian rationing.

Stanvac Elevates J. M. Graham To Chief Process Engineer

John M. Graham has been appointed chief process engineer in Standard-Vacuum Oil Company's Refining Coordination department. Graham resigned his position as assistant supervising engineer in the Standard Oil Development Company's Esso Engineering department to accept the Stanvac appointment. He is a graduate of Massachusetts Institute of Technology and was employed by Calco Chemical Company prior to joining Standard Oil Development Company.

Graham

Congressional Money Group Lauds Oil Industry's Work

Senator O'Mahoney, chairman of the Senate Armed Services Appropriation Sub-Committee, has appeared before the National Petroleum Council and publicly commended the oil industry for the prominent part it is planning in the defense effort and for splendid cooperation given the government in seeing that defense dollars are being spent judiciously.

The NPC committee on synthetic liquid fuels costs said its final report would be ready for presentation at the next NPC meeting.

1951 Net Earnings Up For 20 Major Oil Companies

Combined 1951 net earnings after taxes of 20 major oil companies were 20.5 percent higher than 1950 net earnings of the same companies. Among individual companies, Continental was the only one to report a decline, amounting to 20.6 percent. Increases ranged from less than one percent for Cities Service to more than 62 percent for Union Oil of California.

Rabling Elected Director On Standard-Vacuum Board

Harold Rabling has been elected to the board of directors of Standard-Vacuum Oil Company. He has been chairman and managing director of a subsidiary, Vacuum Oil Company, Pty., Ltd., at Melbourne, Australia, since 1945.

Iran Signs Oil Agreement With Three Norse Nations

The Iranian Oil Sale Commission has announced agreements have been signed by Iran for the sale of 2,500,000 metric tons of crude oil to Denmark, Norway

ELIMINATE PITTING AND CORROSION... *Like This!*

It's no secret that one of the biggest headaches of corrosion control in cooling water systems is the continuance of pitting and tuberculation. Many conventional water treatment methods attempt to overcome this problem by the use of excess treatment concentrations. However, this has been found to be expensive and not altogether successful.

But here's welcome news: Betz Laboratories, after long and careful research, has developed the Dianodic Method which positively assures freedom from scale, protection against corrosion and *elimination of pitting and tuberculation!*

Basically, the Dianodic Method consists of employing a combination of two anodic inhibitors in such a way as to produce results superior to any present water treatment. This advanced technique effectively eliminates pitting and tuberculation, and at the same time provides increased protection against general corrosion.

Results are outstanding! A plant employing polyphosphate treatment encountered severe corrosion, tuberculation and plugging of heat exchangers with corrosion products. Tubercles from ½ to 3 inches in length were found throughout the entire system. Often it was necessary to drill some of the heat exchangers at 30 day intervals to remove accumulated corrosion products. Then the Betz Dianodic Method was used. It was necessary to set up a cleaning program after the application of the Dianodic Method to remove the sloughed off corrosion products that accumulated. After three months operation, this cleaning program was discontinued. *No new pitting or tuberculation has occurred!* Heat exchangers are now inspected and cleaned only at the normal annual turn around.

This is just one example of how Betz *Specialized* Water Conditioning Service is increasing efficiency and cutting costs in plants throughout industry. Why not let Betz show you how to improve results at *your* plant? There's no obligation on your part. W. H. & L. D. BETZ, Gillingham & Worth Streets, Philadelphia 24, Pa. In Canada: Betz Laboratories Limited, Montreal 1.

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TOTAL COST—½ MILL PER BBL.

This 57' x 150' Hardinge Rectangular Clarifier is treating 107,000 barrels of waste water daily—removing the floating oil and solids at a total operating cost of one-half mill per barrel, or 0.0012 cents per gallon. Approximately 50 barrels of oil per day are recovered.

The influent contains 3 to 5 milliliters per liter while the effluent tests show two-tenths to four-tenths milliliters per liter. Waste is treated with 25 to 45 p.p.m. aluminum sulphate and 5 to 9 p.p.m. activated silica.

Operating costs include labor, chemicals, repair, maintenance, taxes and utilities.

This is but one of the many installations where Hardinge equipment is playing an important part in the ever-growing waste treatment picture. Write us about your waste treatment problem today.

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The Month...

and Finland according to press reports. The announcement said delivery would begin in 25 days. Purchasers have made arrangements with Spanish tankers to carry oil to Italy where it would be refined. It was also announced that Hussein Makki, secretary-general of the Oil Nationalization Board, has been invited to visit the U. S. by the International Bank vice president, Robert Garner.

Whiting Personnel Changes Made by Standard of Indiana

Standard Oil Company (Indiana) has made three personnel changes at its Whiting, Indiana, research laboratories. L. W. Russum has been promoted to section leader heading the process economics section of the process division. W. E. Kennel has been advanced to group leader of the process design and economics group of the chemical products division to succeed Dr. Russum. E. W. Kane has been promoted to group leader in the process economics section of the process division.

Cooke Succeeds Houghton As Gulf Patent Counsel

Gulf Oil Corporation has announced that Alfred M. Houghton has relinquished his duties as patent counsel, but will continue in the service of the Gulf companies as consulting patent counsel. Horace B. Cooke will succeed Houghton as patent counsel, and Gordon A. Kessler has been appointed assistant patent counsel. Houghton has been patent counsel for the Gulf Companies since 1914, originally as an attorney in private practice in Washington, D. C., and since 1944 he has been head of the Patent department of the Corporation.

B-A Elevates Roy Campbell To Chief Chemist Capacity

Roy O. Campbell, a graduate of the University of Missouri in chemical engineering, has been appointed chief chemist of the British American Oil Company Limited. He joined B-A in 1931 as resident chemist at the Toronto refinery and has held a number of important positions in the company. Since 1949 Mr. Campbell has been technical assistant in the marketing department.

Mid-Continent Superintendent Dies After Extended Illness

F. Earl Kearney, 59, of Tulsa, Okla., superintendent of the gasoline department, Mid-Continent Petroleum Corporation, died April 28 after an extended illness. He had been with Mid-Continent and its predecessor, the old Cosden Oil Company for 35 years and had resided in Tulsa since 1914.

SoVac Appoints Apjohn Wholesale Division Head

T. L. Apjohn has been appointed manager of the wholesale division of the lubricating department of Socony-Vacuum Oil Company, Inc. Apjohn was formerly supervisor of the products division of the company's research and development department at Paulsboro, N. J. During 1951 he served with the Petro-

The Month...

leum Administration for Defense as assistant director of refining and director of the aviation fuels program.

S. A. Metzger Added to Macco Staff as Construction Head

Stanley A. Metzger has joined the Macco Corporation as manager of its Refinery Construction department. Metzger has been actively engaged in refinery construction work for the past twenty-two years, having done work on plants in Palestine and France as well as numerous assignments throughout the United States. He is a native of California where he finished his schooling. Macco officials say that Metzger's experience will round out that part of the organization which has been engaged in refinery construction and maintenance work for several years.

Metzger

Williams Leaves OPS Post, Returns to Esso Standard

Roger W. Williams, refining section chief, Petroleum Branch, Office of Price Stabilization, has left his post to return to Esso Standard Oil Company. Loring T. Cramer, Petroleum Branch head, said that the post will be filled as soon as possible but no particular person is being considered at present.

Boland Named Sales Manager By Beryllium Corporation

The Beryllium Corporation has announced the appointment of Lawrence F. Boland as sales manager. He has been associated with the firm since 1935 and is being advanced from the position of production control manager to assume his new position.

M. T. Carpenter Appointed Assistant PAD Refining Head

Morris T. Carpenter of The Standard Oil Company (Indiana) has replaced Walter C. Huffman, Sun Oil Company, as assistant director of PAD's Refining Division. Huffman had held the post since 1950 and for the previous year had been assistant director of PAD's aviation fuels program.

Ragland, Sweeney Named To VP Posts at Richfield

Reginald W. Ragland, general counsel and assistant to the president, and Stender Sweeney, personnel director, have been named vice president of the Richfield Oil Corporation.

Shell Tops Safety Record

Shell Development Company topped its 1951 safety record recently when the number of consecutive man-hours worked without a disabling injury passed the two-million mark. The company's 1951 record was 1,280,370 hours.

Announcing a New

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headline achievement–a truly sensational step in the science of Chemical Mixing–a new and important concept in the field of Fluid Agitation . . .

The INTERNATIONAL STABILIZER-BAFFLE stems from International's pioneering research in the Science of Mixing as a basic Chemical Engineering Unit Operation. • It prevents ineffective mass rotation and creation of a liquid vortex. • It induces top-to-bottom turnover instead of non-useful horizontal swirl. • It is an anti-settling and anti-layering device, improving the flow pattern produced by helical propeller type mixing elements.

The INTERNATIONAL STABILIZER-BAFFLE eliminates the whipping of free-end suspended vertical mixer shafts, with no appreciable side thrust exerted on the shaft. It prevents shaft failures which would otherwise occur from critical speed considerations. It makes possible the use of long thin shafts, up to 10 ft. in length, without the use of steady bearings or step bearings. It eliminates the need for submerged bearings with their attendant maintenance and repair problems. Consumes little space and need not rest on the bottom of tank. Thus, there is not the usual "dead" volume as with ordinary tank baffles. It can be readily removed for cleaning purposes, if necessary. Informative Literature sent on request.

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- ☐ CATALOGS 73 & 76 ON TOP AND SIDE ENTERING AGITATORS
- ☐ CATALOG 130 ON CHEMICAL PROCESSING EQUIPMENT

These two photographs illustrate the startling difference in flow pattern, occuring with and without the INTERNATIONAL STABILIZER BAFFLE, under exactly the same conditions. The shaft speed, propeller and rheological properties of the mix being the same in both cases . . . Impeller is center-mounted operating Counter-clockwise at 1750 RPM. Turnover and overall Agitation in above photograph is effected by splitting of helical stream, causing the flow to follow a radial path to the tank wall, and thence upward.

Above photograph shows the deep vortex and poor solids distribution, without the INTERNATIONAL STABILIZER BAFFLE. Note that there is little top to bottom turnover and inefficient flow pattern.

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(A6) Allis-Chalmers Manufacturing Co. 5
(A7) Allis-Chalmers Manufacturing Co. 7
(A8) Aluminum Company of America 220
(A9) American Cyanamid Co. 198
(A10) American Meter Co. 36-37
(B1) The Annin Co. 40
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(B3) Attapulgus Clay Co. 71
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The Handy Postcards → *Get Quick Action*

New Catalogs AND EQUIPMENT LITERATURE

For copies of the catalogs and new equipment literature listed, use one of the convenient Reader Service Postcards on this page. Just circle the number on the card corresponding to the number of the item in which you are interested.

Catalytic Apparatus

Solatone Catalytic Apparatus especially created for hydrocarbon treatment is described in a bulletin by A. B. Hydrocarbon Systems, and provides a sequel to the Sola and Solavite units.

Circle No. 1 on Postcard

Resin Protective Coatings

Technical Bulletin No. 501, published by Prufcoat Laboratories, provides resistance ratings of standard series Prufcoat, "A" series Prufcoat and Prufcoat BX White Enamel to some 69 corrosive chemicals in both concentrated and dilute form.

Circle No. 2 on Postcard

Chest-Mounted Faceshield

Improved vision and elimination of "dead air" space are features advertised by Mine Safety Appliances Company for its new chest-mounted faceshield. Supported by neck and chest straps which provide balanced weight distribution, the shield is equipped with a soft, pliable leather pad which rests on the chest.

Circle No. 3 on Postcard

Electric Motor

Wagner Electric Corporation's complete line of single-phase and polyphase motors includes electrical types with current and torque characteristics to meet most requirements. Further information is contained in a Wagner brochure.

Circle No. 4 on Postcard

pH Control Processing

Scientific cleaning and processing through pH control is the subject of new literature just published by Kelite Products, Inc. Applying only to petroleum industry problems, the new brochure is well illustrated and deals with typical cleaning jobs in all phases of the industry.

Circle No. 5 on Postcard

Welding for Steel Casting

"Recommended Practice for the Welding of Steel Castings" is published by the Steel Founders' Society of America and contains authoritative expositions on the subject, and is available to engineers and technicians who make requests on business letterhead.

Circle No. 6 on Postcard

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New Catalogs AND EQUIPMENT LITERATURE

Use one of the free and convenient Reader Service Postcards on this page to request copies of the catalogs in which you are interested.

Fuel Oils and Additives

E. F. Drew & Company, Inc., has announced the availability of a technical folder on problems concerned with the burning of modern fuel oils and the application of additives. The folder presents data and information based on research aimed at the elimination of sludge, soot and slag in the burning of industrial fuel oil.

Circle No. 7 on Postcard

Expanded Facilities

"Allegheny Ludlum Serves The West," a new bulletin which describes the expanded facilities of the Allegheny Ludlum Steel Corporation, has recently been published. Data on equipment and production of the company's Los Angeles forge plant, warehouses at Los Angeles and San Francisco and sales branch at Seattle is included.

Circle No. 8 on Postcard

Corrosion Proof Plastic Pipe

Flexible and rigid plastic pipe for every piping need is now manufactured by the Plastex Pipe and Extrusion Company, engaged in custom extrusion of plastics. Plastex corrosion proof pipe has positive resistance against rust, rot and electrolytic corrosion.

Circle No. 9 on Postcard

PETROLEUM REFINER Reader Service Postcard—May, 1952, Issue*

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1	4	7	10	13	16	19	22	25	28	31	34	37	40	43	46	49	52	55
2	5	8	11	14	17	20	23	26	29	32	35	38	41	44	47	50	53	
3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	

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A2	B2	C2	D2	E2	F2	G2	H2	J2	K2	L2	M2	N2	P2	Q2	R2	S2	T2	U2
A3	B3	C3	D3	E3	F3	G3	H3	J3	K3	L3	M3	N3	P3	Q3	R3	S3	T3	U3
A4	B4	C4	D4	E4	F4	G4	H4	J4	K4	L4	M4	N4	P4	Q4	R4	S4	T4	U4
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A6	B6	C6	D6	E6	F6	G6	H6	J6	K6	L6	M6	N6	P6	Q6	R6	S6	T6	U6
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A9	B9	C9	D9	E9	F9	G9	H9	J9	K9	L9	M9	N9	P9	Q9	R9	S9	T9	U9
A10	B10	C10	D10	E10	F10	G10	H10	J10	K10	L10	M10	N10	P10	Q10	R10	S10	T10	U10

Name (Please Print)_____

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High-Temperature Distillation

Minneapolis-Honeywell Regulator Company describes the Podbielniak apparatus with multi-range Electronik potentiometer for high temperature frequency distillation studies in this Instrumentation Data Sheet publication.

Circle No. 10 on Postcard

Oilers and Supply Cans

The New Gem Manufacturing Corporation catalog No. 100, contains complete descriptions, specifications, capacities, etc., of Gem's complete line of welded steel bench and pump oilers and supply cans for machines.

Circle No. 11 on Postcard

Plastic Safety Lenses

American Optical Company has perfected plastic safety lenses which are manufactured in a unique air-conditioned room where they are "baked" in glass molds. Half the weight of the glass counterpart, the plastic lens is highly resistant to breakage.

Circle No. 12 on Postcard

Process Machinery

Hardinge Company, Inc., has just published a new bulletin describing its complete line of process machinery for mining, chemical, industrial wastes, etc., applications. Among process operations covered are: agitating-mixing; clarifying; filtering; and scrubbing.

Circle No. 13 on Postcard

(More Literature Items on Pages 193, 196, 197, 199.)

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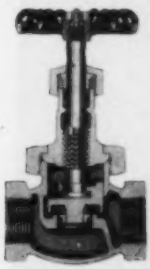
NEW EQUIPMENT and Manufacturers' Literature

KEEP INFORMED by requesting additional information on new equipment and services described here. SAVE TIME by using the Reader Service Postcards on opposite page. Circle number on card corresponding to the number listed at the end of each new equipment item on which you desire additional information.

Globe, Angle and Check Valves

These valves are available in the globe, angle and check patterns in sizes ranging from ¼ to 3-inches inclusive from the Ohio Injector Company, and featuring an OIC synthetic disc and packing as seat and seam seal. All types and sizes have a union bonnet connection with spherical seat against a 45-degree angle on the body forming a line contact joint which may be dismantled many times with no harm to the seats. OIC LPG valves are widely used for butane, propane, butylenes, propylenes and other volital fluids. Stems are OIC 40 alloy giving 20 to 30 times the service life of old stem materials, manufacturers claim, and are Underwriter's approved for liquefied petroleum gas service.



Circle No. 14 on Postcard

Thermocouple Glands

Conax Thermocouple Gland bulletin has been made available by Conax Corporation. It describes Thermocouple Glands, which are designed for use with bare wire, and which gives a table on Thermocouple Wire.

Circle No. 15 on Postcard

Purifier

Warranted to remove more than 99 percent of entrainment, the new Type LC Hi-eF purifier made by the V. D. Anderson Company for smaller pipelines from ½ to 2-inches, is installed like a valve or steam trap. It is applicable for cleaning up steam processing lines to get bettter production out of kettles, etc., to protect small engines, turbines, and regulating equipment from pipe scale; to remove entrainment from vapor lines following evaporation; and similar tasks. The improved centrifugal element within the unit engages and imparts a rapid rotational motion to entrainment laden vapor, throwing the solids and water outward to the walls of the purifier.

Circle No. 16 on Postcard

Floating Roof Storage Tanks

Outlining construction, operating features and other pertinent data, bulletin has been issued on double-deck, floating roof tanks by the manufacturer, Graver Tank & Manufacturing Company, Inc. The publication contains an explanation and illustrations on the seal and seal mechanism of the tanks along with examples of product conservation through the use of the floating roof tank. A graph on average standing losses from floating roof tanks is featured, as well as a listing of standard and special accessories.

Circle No. 17 on Postcard

Pyrometer Controller Unit

A direct reading, indicating pyrometer controller incorporating a built-in unit to provide straight-line control is being offered by Wheelco Instruments Company, and provides a means of securing a type of proportioning control for processing equipment. The instrument operates with the Wheelco "Electronic Link," but adds the new "Line-otrol" feature to automatically reduce to a minimum the "on" and "off" variation of the control instrument above and below the preset control point. Called, "Capacitrol," the instrument features Thermocouple Break protection, interchangeable voltage selector plugs, front accessibility and plug-in terminal panel.

Circle No. 18 on Postcard

Instruments Catalog

Minneapolis Honeywell, Brown Instruments Division, has published a Composite Catalog describing principal instruments, control devices and related components manufactured by the company.

Circle No. 19 on Postcard

Stainless Steel Fittings

A new line of corrosion resistant stainless steel fittings has been announced by the Special Screw Products Company for schedule 5S and 10S tubing. Included is a standard selection of elbows, tees, unions and connectors for tubing sizes up to and including 3/4-inches, with couplings for larger diameters handled on special order. All Koncentrik Fittings incorporate the self-centering seat that insures leak-proof, wedge-type seal and reinforcing Teflon rings that double-seal the seat against gas or liquid losses.

Circle No. 20 on Postcard

Time-Temperature Control

A new Minneapolis-Honeywell Regulator Company catalog called "Cam Programmer Thermometers," describes a compact efficient approach to the problem of time-temperature control. Use, advantages, technicalities and versatility of the instrument are discussed.

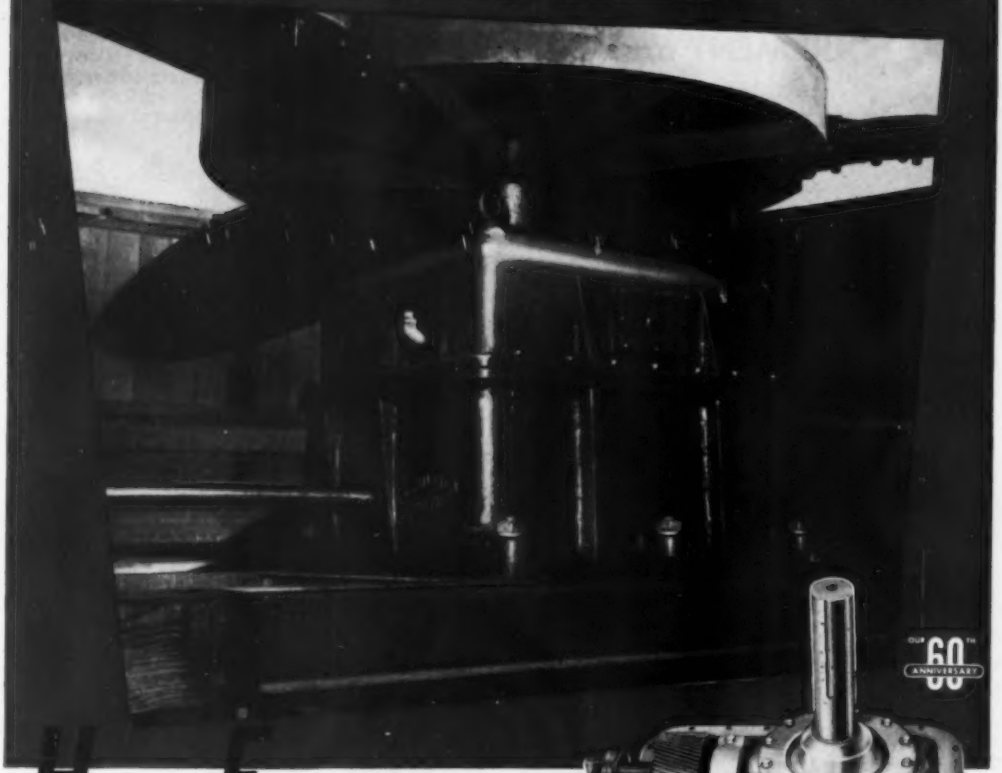
Circle No. 21 on Postcard

Automatic Fire Extinguisher

A corrosion and rust-proof automatic fire extinguisher has been introduced by Red Comet, Inc., which is made of fire-resistant plastic with the few small metal parts being cadmium plated. The extinguisher contain carbon tetrachloride sealed in a glass container. A fusible clip and coiled spring release the fluid. A detachable top can be removed so the extinguishing fluid can be used manually if desired. The unit is available in red or ivory colors for installation where appearance may be important. A replacement award accompanies each unit, guaranteeing a one-half reduction in the price of a replacement unit.

Circle No. 22 on Postcard

PHILADELPHIA SPIRAL-BEVEL COOLING TOWER DRIVE



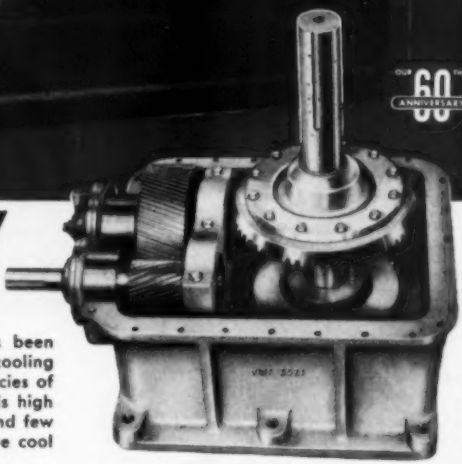
HIGH EFFICIENCY

CUTS POWER LOSS

The Philadelphia Spiral-Bevel Cooling Tower Drive has been developed to transmit the heavier fan loads of today's cooling towers. Many of these units are now operating at efficiencies of 97-98% under the most severe operating conditions. This high efficiency means minimum power loss, less maintenance and few oil changes during the long life of the reducers. Units are cool operating.

A wide range of sizes are available for every cooling tower application.

The drive shown above is on a cooling tower designed and built by Hudson Engineering Company. It is typical of many such installations.



Construction features of the Philadelphia Spiral-Bevel Cooling Tower Drive are given in Bulletin CT-51. Write on your business letterhead for a copy.

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA.

Industrial Gears and Speed Reducers
LimiTorque Valve Controls

Firebricks

"Better Refractories For The Furnaces of Industry" describes the various brands of fire clay brick, high alumina brick, silica brick and refractory specialties made by Mexico Refractories Company for varied applications in industrial furnaces. A tabular presentation of the type of firebrick recommended for most all typical industrial applications, and characteristics of firebrick are briefly described.

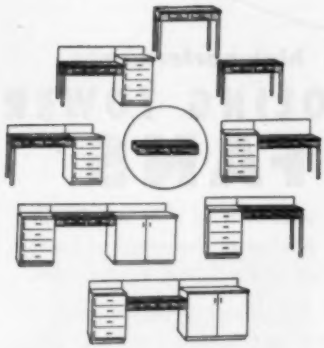
Circle No. 23 on Postcard

Proportioning Weir Tank

The Omega Machine Company has developed a line of proportioning weir tanks for solutions or suspensions which includes a specially constructed tank incorporating a stilling chamber, an accurately machined rectangular weir, two outlet chambers and a flow splitter, so arranged that the total flow of solution or suspension to the two outlets can be readily divided into any proportion.

Circle No. 24 on Postcard

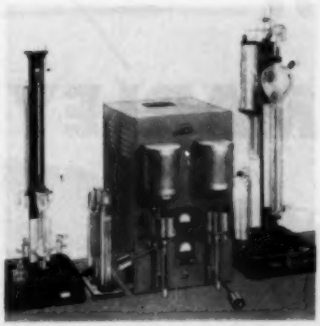
Laboratory Furniture Unit



The Versa-Table, a new furniture unit, has been added to the line of Unitized furniture manufactured by the Fisher Scientific Company to meet a laboratory's need for 30 to 48 additional inches of working space. As many as eight different methods of installation are possible to suit the existing or proposed physical layout of the laboratory. The stable can be positioned at either end of a Unitized furniture assembly at one of two heights by making use of a single pair of 30-inch or 36-inch high legs. The upper section of the Versa-Table is constructed of heavy gauge steel which can be topped with stainless steel, Kemrock or Formica. In addition to working tops, reagent shelves may be had for the new unit. Two drawers conveniently hold those items used most by the laboratory workers while at the table.

Circle No. 25 on Postcard

Carbon, Sulfur Analyses



The new Leco Model IH-15 induction furnace for carbon and sulfur analyses is a unit with two combustion tubes designed so gasometric or gravimetric carbon analyses can be made from the combustion tube on one side, and sulfur analyses from the tube on the other side. The carbon side has a combustion tube with a patented jet, while the sulfur side has a special large combustion tube and a large inductor coil. The design of the unit is such that no grid tap switch is needed. The unit is commonly used with a Leco sulfur titration unit and a purifying train with rotometer tower.

Circle No. 26 on Postcard

Alkaline Derusting Process

A new alkaline derusting process for steel, cast iron, etc., produced by Enthone, Inc., and requiring no acid in the procedure, eliminates the possibility of high carbon steel discoloration and subsequent rusting by virtue of the acid attack on the base metal. The work to be derusted is made the cathode in a solution of Enthone Derusting Compound for a few seconds or minutes depending on the work to be accomplished.

Circle No. 27 on Postcard

Automatic Program Controller

Builders-Providence, Inc. has announced the availability of the APC—Automatic Program Controller—which is a simple and accurate device for controlling the feed of chlorine at predetermined periods in identical cycles to meet variations in chlorine demand as they may occur.

Circle No. 28 on Postcard

Resistance Thermometers

General purpose and specialized Thermohms to detect temperatures between minus 320° and 1000° F. with accuracies from .018° to 3.0° F. are fully described in a new catalog issued by Leeds & Northrup Company.

Circle No. 29 on Postcard

Plastic Reinforced Tubing

The Reflin Company, has announced the availability of its new plastic and Fibreglas-reinforced plastic tubing, REFLIN, in commercial quantities. Lightweight, strong and corrosion resistant, the new tubing will give engineers "a new design material for vital defense applications and a substitute for presently-used materials in critically short supply." The new tubing is suitable for housing of air-borne equipment and components, standpipes and vent tubes, oil gathering lines, irrigation lines, salt-water piping, electrical conduits, sanitary piping and natural gas pipelines.

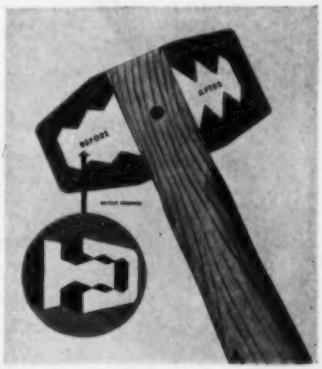
Circle No. 30 on Postcard

Impulse-Type Turbines

Six new bulletins describing the Pyle-National Company's line of high-efficiency impulse type steam, gas or air turbines for mechanical drive, have just been released. One of the bulletins is devoted to each of the five types of turbines available, ranging from ¼ to 120 hp., giving performance charts, construction details, dimensions, weights and selection data. The sixth bulletin provides general turbine information.

Circle No. 31 on Postcard

Compression Safety Hammer



Using "Controlled Compression," the Flex-Flo Safety Hammer consists of a malleable metal hammer having hollow chambers, the inner walls of which are corrugated. Under continuous heavy pounding, the opposing angles of these corrugations slowly approximate each other, thus retarding the compression of the hammer head and preventing mushrooming. Manufactured by the Custanite Corporation, the hammer is made of a controlled non-ferrous copper-base alloy which will not spark, chip or flake. It is available in six weights and sizes from three-quarters of a pound to six pounds.

Circle No. 32 on Postcard

It's TOPS... so it's MARLEY!

high performance
COOLING TOWER FANS

Every Marley fan, whether it be a 72-inch fan or a 264-inch giant, is the product of thousands of hours of Marley research and development.

On the drawing board it is checked and rechecked for engineering exactness. Then begins the long process of testing—first as a scale model, then on to a production model and hundreds of hours in Marley's outdoor laboratory. Here engineering specialists, assisted by finest electronic analysis equipment, check and record its performance under actual operating conditions.

producers of
DOUBLE FLOW TOWERS
DRICOOLERS
AQUATOWERS
NATURAL DRAFT TOWERS
CONVENTIONAL TOWERS
SPRAY NOZZLES
DOUBLE FLOW AQUATOWERS

Once approved for production the vigil does not cease. Every step from pattern making to field installation is rigidly controlled and inspected. All machine processes in the Marley fan department are inspected by trained experts and any error means rejection. Final balancing that means smoothness of operation is done by men with years of training and experience.

This exacting method of development and production is assurance that the fan installed on any Marley cooling tower will do the exact job it is designed for. Actual tests of every kind over long periods have proved it.

MARLEY

The Marley Company, Inc.

Kansas City 5, Missouri

Lightweight Faceshields

Attractive appearance, light-weight and genuine comfort are claimed by the United States Safety Service Company for its new "Halo" faceshield. A new feature is an all-green spark protector which affords wide-angle vision and still eliminates glare from overhead lighting. Another new development is a patented visor lock which locks the visor in the "up position" or the "working position" and eliminates the chance of the wearer adjusting the visor so it does not afford full protection. The shield is also available with an acid resistant visor, with a choice of either clear or green color.

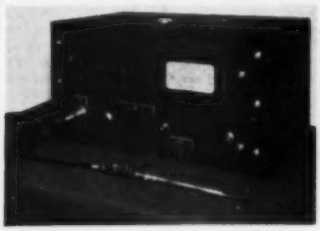
Circle No. 33 on Postcard

Air Compressor Silencers

Engineers of the Burgess-Manning Company has developed equipment which will reduce air-borne air compressor intake noise. Three "snubber" series have been designed which also will meet pulsation problems. The silencing equipment has been prepared to apply to any type and size of compressor and to meet all needs of silencing requirements.

Circle No. 34 on Postcard

Ultrasonic Viscosimeter



The Rich-Roth Laboratories have announced the "Ultra-Viscoson" for continuous, automatic viscosity measurement using ultrasonics. The hermetically sealed probe, the size of a fountain pen, has no moving parts, operates to 650° F., 10,000 atmospheres pressure and can be installed permanently in pipe lines, production kettles or used in test tubes and beakers. An electronic computer, located up to one mile from the probe, indicates viscosity of Newtonian materials and apparent viscosity of non-Newtonian materials. Connection to a recorder or controller provides continuous charts or automatic control.

Circle No. 35 on Postcard

Metal Protective Coating

A progress report is now available on Dum Dum for Metal, a metal protective coating manufactured by The Arco Company. The report summarizes results to date of a continuing series of tests in the field and in the Arco Research Laboratory to determine the extent of protection provided by Dum Dum for Metal. The product is used on any metal structure where there is no abraision problem.

Circle No. 36 on Postcard

Power Plant Flow Diagram

A composite flow diagram of a typical steam electric generating station operating at pressure between 250 and 2500 psi., prepared by the engineering staff of Edward Valves, Inc., is now available upon request. The 11 by 20-inch flow diagram illustrates functional lines of a modern power plant, the principal equipment and a large number of valves required for controlling flow in the various piping systems.

Circle No. 37 on Postcard

By-Pass Flow Orifice Meter

The V/A Cell, manufactured by Fischer & Porter Company, introduces a new approach to orifice metering by metering a continuous by-pass stream around the orifice instead of the static-pressure differential across the orifice. The cell permits adjustment of the by-pass rate and is adaptable to pneumatic connection to points remote from the orifice run. The cell is connected across the orifice plate in line with standard orifice metering procedures and can handle pressure differentials up to 1400 inches of water column. By changing range tubes at high-pressure tap, the differential range of the cell can be varied from 50 inches to 1400 inches in standard increments with a usable flow ratio of ten to one at the 200 inch differential. The cell is manufactured in two models: one with working pressure rating of 1040 pounds per square inch at 350° F. or 1200 pounds per square inch at 100° F. the other rated at 2600 pounds per square inch at 350° F. or 3000 pounds per square inch at 100° F. It can be mounted at the orifice flange or up to 30 feet from the flange.

Circle No. 38 on Postcard

Centrifugal Sump Pumps

Warren Steam Pump Company has announced improved models of Types VS and VN sump pumps. An eight page bulletin illustrating and describing the pumps is available. Available in wet and dry pit types, the pumps are adapted to handling clear liquids, sewage and other liquids containing solids. Sizes range from 1½ inches to 8 inches, capacities to 1000 GPM and pressures up to 250 pounds per square inch.

Circle No. 39 on Postcard

Automatic Fire Protection

The "Automatic" Sprinkler Corporation of America has made available the industrial application of fixed systems of Automatic Air Foam protection, employing Air Foam, a new fire fighting substance developed several years ago by National Foam Systems, Inc. The engineering design of these Air Foam systems was developed by "Automatic" Sprinkler Corporation for Solvay Process and was based on recommendations by engineers of the Factory Insurance Association. The systems depend upon the integration of deluge sprinkler equipment and a foam injection system. Air Foam is discharged at the rate of two GPM per square foot, equivalent to a floor depth of approximately three inches per minute. More detailed information is available in a brochure published by the firm.

Circle No. 40 on Postcard

Spectrophotometer

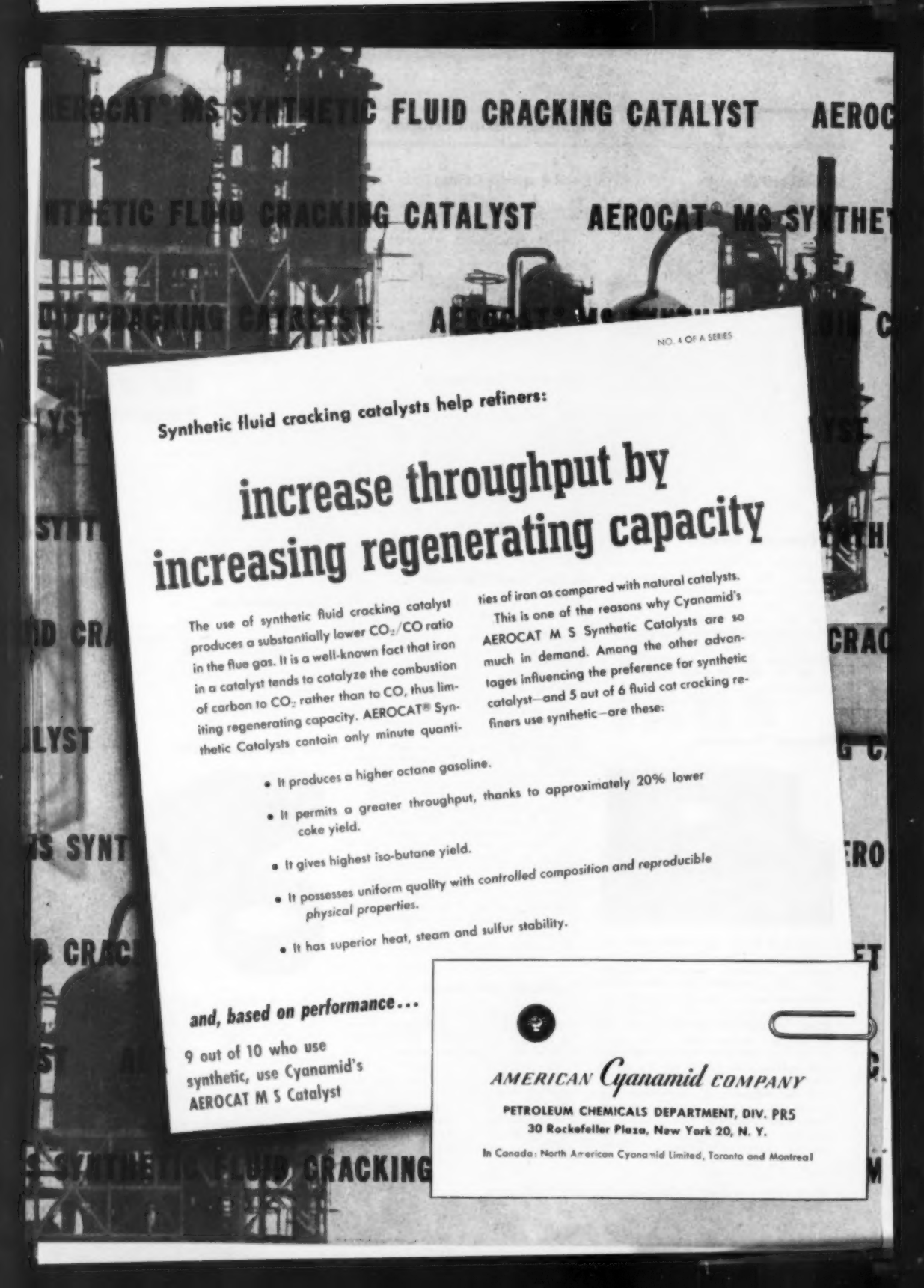
Application, operation and salient features of the new direct transmittancy spectrophotometer produced by the National Technical Laboratories is described in a Minneapolis-Honeywell Regulator Company Instrumentation Data Sheet.

Circle No. 41 on Postcard

New Continuous Packing

The Mechanical Packing division of the Flexrock Company has announced a new, continuous, chevron-type packing designed for 500-6000 pounds per square inch and available in styles for either high or low temperatures. Known as Flexrock "Continuous-Vee" packing, it is furnished in sizes from ¼ inch to one inch, by 1/16 inch increments, 25 feet per spiral. Offered in styles for both high and low temperatures, top and bottom adaptors in continuous form are available for both styles.

Circle No. 42 on Postcard



NO. 4 OF A SERIES

Synthetic fluid cracking catalysts help refiners:

increase throughput by increasing regenerating capacity

The use of synthetic fluid cracking catalyst produces a substantially lower CO_2/CO ratio in the flue gas. It is a well-known fact that iron in a catalyst tends to catalyze the combustion of carbon to CO_2 rather than to CO, thus limiting regenerating capacity. AEROCAT® Synthetic Catalysts contain only minute quantities of iron as compared with natural catalysts.

This is one of the reasons why Cyanamid's AEROCAT M S Synthetic Catalysts are so much in demand. Among the other advantages influencing the preference for synthetic catalyst—and 5 out of 6 fluid cat cracking refiners use synthetic—are these:

- It produces a higher octane gasoline.
- It permits a greater throughput, thanks to approximately 20% lower coke yield.
- It gives highest iso-butane yield.
- It possesses uniform quality with controlled composition and reproducible physical properties.
- It has superior heat, steam and sulfur stability.

and, based on performance...

9 out of 10 who use synthetic, use Cyanamid's AEROCAT M S Catalyst

AMERICAN Cyanamid COMPANY

PETROLEUM CHEMICALS DEPARTMENT, DIV. PR5
30 Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

Temperature Pickup Unit

Trans-Sonics, Inc., has announced a new series of temperature pickups, Type 21, for measuring temperatures up to 1832° F. High voltage output (0-1 volt) is an outstanding feature of the series, and in addition, the short thermal time-constant (less than one second in water) is a new development. These pickups provide a resistance change of 50 ohms over their specified temperature ranges and may be excited with 20 milliamperes, rms. The sensing element of the series is contained within a spade-shaped tip of a stainless steel case. Each instrument is provided with a calibration certificate and the units are guaranteed to have an accuracy of plus one percent of full scale.

Circle No. 43 on Postcard

Cleaner for Gas, Air Lines

A catalog describing the applications, structure and characteristics of the Aridifier, a mechanical cleaner that removes oil, moisture and dirt from compressed gas and air lines has been published by Logan Engineering Company. A few typical installations and aids in selecting the proper size of Aridifier are included.

Circle No. 44 on Postcard

Piston Diaphragm Pumps

Lapp Pulsafeeders, piston diaphragm pumps for controlled volume pumping of fluids, are described in detail in a new catalog issued by Lapp Process Equipment division of Lapp Insulator Company, Inc. Covering construction details of all models, manual control applications, special assemblies and applications are discussed.

Circle No. 45 on Postcard

Vertical Induction Motors

Covering motor ratings in 40 C, 60 cycle from 60 hp, 200 rpm to 800 hp and larger at 1800 rpm, bulletin, "Large Vertical Induction Motors," has been published by the Allis-Chalmers Manufacturing Company. The bulletin describes the characteristics and construction features of vertical solid shaft induction motors built by Allis-Chalmers.

Circle No. 46 on Postcard

Oils, Waxes and Greases

The properties of Kel-F oils, waxes and greases manufactured by the chemical manufacturing division of The M. W. Kellogg Company are described in a new bulletin which also includes data on applications where high temperature properties and high electrical resistance are required. Indicated possibilities where chemical inertness is required is also given special attention.

Circle No. 47 on Postcard

Bulletin On Storage Racks

Applications for and complete information on Barrett Steel Storage Racks for drums, barrels, crates, bins, skids and pallets are contained in a bulletin released by Barrett-Cravens Company. The bulletin demonstrates how storage rack systems solve the need for more floor space without additional construction costs. Information on Barrett handling equipment for handling material in and out of rack storage is included.

Circle No. 48 on Postcard

Motor and Control Booklet

"Undivided responsibility" for application of both motors and their controls to the chemical industry is the theme of a new booklet made available by Westinghouse Electric Corporation. It treats a general application problem that is common to the chemical industry and shows how the co-ordinated application of motors and controls provides the solution. Both internal and external construction details of available motors and controls are described and illustrated.

Circle No. 49 on Postcard

Fractional HP Gear-Motors

A bulletin on fractional horsepower gear-motors listing 61 standard models has been made available by the General Electric Company. The publication describes the applications for FHP gear-motors and outlines a simple method of determining correct horsepower requirements with the use of an ordinary pipe wrench and fish scale. It also contains descriptions, cut-away drawings, selection charts and dimensional tables for both concentric-shaft and right-angle shaft gear-motors, and includes a section on maintenance pointers.

Circle No. 50 on Postcard

Combustion Control Methods

A detailed account of automatic combustion control techniques for oil and gas fired boilers is now available in a bulletin issued by Bailey Meter Company. Illustrations and descriptions include lucid diagrammatics showing nine typical firing methods and 16 major control equipment components. The material also includes facts and figures on individual installations.

Circle No. 51 on Postcard

pH Electrometer

An entirely new appproach to the precise measurement of pH, the Coleman Instruments, Inc., "Compax" pH Electrometer is a self-contained, portable pH Electrometer combining the precision of the linear potentiometer with the complete simplicity of single dial operation. A flashing signal which eliminates meters, pointers, and reset knobs and establishes the reading point with pin point precision, is one of the new features. A bulletin is available.

Circle No. 52 on Postcard

Liquid Roof Coating Booklet

Seal-Kote asphalt and asbestos roof coating is described in a bulletin published by Paramount Industrial Products Company, Inc. The bulletin also includes details on Seal-Kote plastic roof cement and saturant.

Circle No. 53 on Postcard

Caustic Soda Properties

Solvay Sales Division of Allied Chemical & Dye Corporation has expanded and revised its edition of Technical and Engineering Bulletin No. 6 on "Caustic Soda, Properties, Solutions, Unloading and Handling," and offers this fourth edition upon request.

Circle No. 54 on Postcard

Molybdenum Lubrication

"Abstracts, Bibliography and Case Histories of Liqui-Moly (Molybdenum Disulfide) Lubrication" is the title of a new technical bulletin offered by The Lockrey Company. The bulletin contains a complete listing of the current reference-literature, a list of pertinent patents and a summary of two years of case histories of field applications of Liqui-Moly lubricants. Forty-two references are quoted or listed, including the investigations of the National Advisory Committee for Aeronautics.

Circle No. 55 on Postcard

AMERICA'S LEADING INDUSTRIES PUT THE STAMP OF APPROVAL ON KIELEY & MUELLER CONTROL VALVES

Make It Your Business to Find Out Why!

All over the country leading companies in the process industries are solving tough problems with K & M control valves, designed especially for precise and positive control by instrumentation.

More and more, as the outstanding performance of these superbly engineered valves becomes known, important companies with pressure and flow applications are turning to K & M for the skill, knowledge and experience that assure reliable automatic control of pressures, temperatures, rates of flow and liquid levels.

There is a qualified K & M representative near you, eager to discuss your control problems and able to provide the most satisfactory solution.

This extremely accurate circular slide-rule type K & M valve capacity calulator includes correction scales for steam quality, liquid and gas specific gravity and a flowing temperature scale for gases. Sent without charge in response to a request on your business stationery.

K&M

KIELEY & MUELLER, INC.

Valve Makers Since 1879

2033 - 43rd STREET NORTH BERGEN, N. J.

Catalogs AND EQUIPMENT *Literature* OFFERED IN THIS ISSUE'S ADVERTISEMENTS

Copies may be obtained easily and without cost by using Reader Service Postcard. Just circle on the card the identifying key number of each item in which you are interested. Postcards are opposite page 192.

CEMENT, CONCRETE AND CASTABLE REFRACTORY GUNS—Catalog. Aire Placement Equipment Co. See page 268.
Circle A1 on postcard.

HARDFACING ALLOYS—Information. Air Reduction Magnolia Co. See page 60.
Circle A3 on postcard.

TUBE CLEANERS AND EXPANDERS—Data. Airetool Manufacturing Co. See page 227.
Circle A4 on postcard.

STEEL FLOOR PLATE—Booklet A-18. Alan Wood Steel Co. See page 225.
Circle A5 on postcard.

TUBE TYPE MOTORS—Bulletin 51B7149. Allis-Chalmers Manufacturing Co. See page 5.
Circle A6 on postcard.

BLOWING EQUIPMENT—Bulletin 19B6104A. Allis-Chalmers Manufacturing Co. See page 7.
Circle A7 on postcard.

CONTROL VALVES—Catalog 1500B. The Annin Co. See page 40.
Circle B1 on postcard.

SCRUBBING TOWERS—Catalog. Aqua-Therm, Inc. See page 267.
Circle B2 on postcard.

TURBINE TYPE PUMPS—Bulletins. Aurora Pump Co. See page 257.
Circle B4 on postcard.

PIPE AND BOLT MACHINES—Catalog. Beaver Pipe Tools, Inc. See page 261.
Circle B8 on postcard.

pH EQUIPMENT—Bulletin 1-131. Beckman Instruments, Inc. See page 46.
Circle B9 on postcard.

WATER CONDITIONING SERVICE—Data. W. H. & L. D. Betz. See page 189.
Circle C1 on postcard.

VENT VALVE FLAME ARRESTOR—Bulletin 601. Black, Sivalls & Bryson, Inc. See page 72.
Circle C2 on postcard.

STEEL FLOORING—Bulletin 2365. Blaw-Knox Co. See page 257.
Circle C4 on postcard.

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS—Catalog. The Bristol Co. See pages 26 and 27.
Circle C6 on postcard.

HEAT EXCHANGERS—Bulletin 481. The Brown Fintube Co. See page 230.
Circle C8 on postcard.

LIFT-PLUG VALVES—Literature. Cameron Iron Works, Inc. See page 70.
Circle D1 on postcard.

SEAL UNIONS—Catalog 11. Catawissa Valve & Fittings Co. See page 260.
Circle D3 on postcard.

GATE VALVES—Catalog 10. The Chapman Valve Manufacturing Co. See page 236.
Circle D4 on postcard.

CONDENSER AND HEAT EXCHANGER TUBES—Booklet. Chase Brass & Copper Co. See page 86.
Circle D5 on postcard.

MOTOR DRIVEN COMPRESSORS—Bulletin 118. Clark Bros. Co. See page 251.
Circle D8 on postcard.

STEEL GATE VALVES—Circular AD-1881. Crane Co. See page 173.
Circle D10 on postcard.

TUBE FITTINGS—Catalog. Crawford Fitting Co. See page 266.
Circle E1 on postcard.

TANK SUCTION HEATERS—Literature. Davis Engineering Corp. See page 219.
Circle E4 on postcard.

STEAM TURBINES—Data. Dean Hill Pump Co. See page 255.
Circle E7 on postcard.

REFINERY PUMPS—Bulletin. De Laval Steam Turbine Co. See page 41.
Circle E8 on postcard.

WATCHMEN'S CLOCKS—Folder. Detex Watchclock Corp. See page 250.
Circle E10 on postcard.

INSULATING MATERIALS—Data. The Eagle-Picher Co. See pages 30 and 31.
Circle F4 on postcard.

INSULATING MATERIALS—Booklet. Earl Paint Corp. See page 56.
Circle F5 on postcard.

OUTDOOR SPLASHPROOF MOTORS—Bulletin PB 7000-3. Elliott Co. See page 82.
Circle F6 on postcard.

TUBE CLEANERS—Bulletin Y-29. Elliott Co. See page 205.
Circle F7 on postcard.

EXPLOSION-PROOF INTERCOM SYSTEM—Literature. Executone, Inc. See page 233.
Circle F9 on postcard.

DIAPHRAGM MOTOR VALVE—Bulletin E-5700. Fisher Governor Co. See page 63.
Circle F10 on postcard.

CAT-CRACKERS—Bulletin CC2521. The Fluor Corp. See page 57.
Circle G4 on postcard.

FLUID HYDROFORMING—Brochure O-52-3. Foster Wheeler Corp. See page 42.
Circle G5 on postcard.

RECORDING AND CONTROLLING INSTRUMENTS—Catalogs. Gotham Instruments. See page 55.
Circle G7 on postcard.

STORAGE TANK OIL HEATERS—Bulletin. The Griscom-Russell Co. See page 50.
Circle G9 on postcard.

MIXING EQUIPMENT—Catalogs. International Engineering, Inc. See page 191.
Circle H5 on postcard.

WIRE MESH PRODUCTS—Information. The C. O. Jelliff Mfg. Corp. See page 261.
Circle H8 on postcard.

STEAM GAGE UNITS—Data. Jerguson Gage & Valve Co. See page 266.
Circle H9 on postcard.

BLOCK INSULATION—Brochure IN-134A. Johns-Manville Corp. See page 62.
Circle H10 on postcard.

EMERGENCY RELIEF VENTS—Catalog. The Johnston & Jennings Co. See page 217.
Circle J1 on postcard.

HEAT INSULATION—Book. Kaylo Division. See page 215.
Circle J2 on postcard.

ASBESTOS-CEMENT STRUCTURAL BOARDS—Data. Keasbey & Mattison Co. See page 75.
Circle J3 on postcard.

STEEL GRATING—Catalog. Kerrigan Iron Works, Inc. See page 242.
Circle J5 on postcard.

VALVE CAPACITY CALCULATOR—Sample. Kieley & Mueller, Inc. See page 200.
Circle J6 on postcard.

LIQUID PUMPS—Bulletin L51. Kinney Manufacturing Co. See page 261.
Circle J8 on postcard.

BUBBLE TRAYS—Information. Koch Engineering Co. See Third Cover ad.
Circle J10 on postcard.

INDUSTRIAL COOLING FANS—Data. Koppers Co. See page 268.
Circle K1 on postcard.

WATER DEVELOPMENT SERVICES—Catalog. Layne & Bowler, Inc. See page 245.
Circle K3 on postcard.

CAST STEEL VALVES—Booklet. The Lunkenheimer Co. See page 272.
Circle K7 on postcard.

MIST ELIMINATORS—Bulletin. Metal Textile Corp. See page 264.
Circle L4 on postcard.

CONTROLLED VOLUME PUMPS—Bulletin 251. Milton Roy Co. See page 66.
Circle L7 on postcard.

RECORDING AND CONTROLLING INSTRUMENTS—Catalog 5000. Minneapolis-Honeywell Regulator Co. See pages 80 and 81.
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HEAT INSULATION—Information. Mundet Cork Corp. See page 259.
Circle M1 on postcard.

STEAM TURBINES—Bulletin T-122. Murray Iron Works Co. See page 259.
Circle M2 on postcard.

CORROSION PREVENTION PRODUCTS—Information. The Natasco Co. See page 224.
Circle M3 on postcard.

CATHODIC PROTECTION—Catalog Section S-6510. National Carbon Co. See page 202.
Circle M5 on postcard.

STEEL TUBING—Bulletin 26. National Tube Division. See page 218.
Circle M6 on postcard.

STEAM TRAPS—Bulletin 451. W. H. Nicholson & Co. See page 262.
Circle M7 on postcard.

SOLVENT DETERGENTS—Booklet. Oakite Products, Inc. See page 238.
Circle M10 on postcard.

GREASE PROCESSING UNITS—Information. The Patterson Foundry & Machine Co. See Back Cover ad.
Circle N4 on postcard.

PROCESS PUMPS—Bulletin B-1605. Peerless Pump Division. See page 185.
Circle N5 on postcard.

SPIRAL BEVEL COOLING TOWER—Bulletin Ct-51. Philadelphia Gear Works, Inc. See page 194.
Circle N9 on postcard.

MICRO-FEEDERS—Bulletin SM-3005-2. % Proportioneers, Inc%. See Second Cover ad.
Circle P3 on postcard.

FIRE FIGHTING EQUIPMENT—Data. Pyrene Manufacturing Co. See page 235.
Circle P4 on postcard.

STAINLESS AND HEAT-RESISTING STEELS—Data. Republic Steel Corp. See page 33.
Circle P7 on postcard.

CONDENSER TUBES—Booklet. Revere Copper & Brass, Inc. See page 169.
Circle P9 on postcard.

DIAL THERMOMETERS—Information. Rochester Manufacturing Co. See page 253.
Circle Q1 on postcard.

BUTTERFLY AND SLIDE VALVES—Catalog. W. S. Rockwell Co. See page 262.
Circle Q2 on postcard.

BALL VALVES—Bulletin V-4. Rockwood Sprinkler Co. See page 20.
Circle Q4 on postcard.

CONDENSER TUBES—Booklet. Scovill Manufacturing Co. See page 6.
Circle Q6 on postcard.

PUMP VALVES—Catalog. Sims Pump Valve Co. See page 213.
Circle Q10 on postcard.

DUAL ORIFICE ASSEMBLY—Catalog 68-R. Strong, Carlisle & Hammond Co. See page 229.
Circle R4 on postcard.

MIXING EQUIPMENT—Information. Struthers Wells Corp. See page 21.
Circle R5 on postcard.

FORGED STEEL FLANGES—Data. Taylor Forge & Pipe Works. See page 47.
Circle R8 on postcard.

MULTISAGE TURBINES—Bulletin S-146. The Terry Steam Turbine Co. See ad opposite page 97.
Circle R9 on postcard.

STEAM TURBINES—Information. Whiton Machine Co. See page 253.
Circle T3 on postcard.

TUBE EXPANDERS—Data. The Gustav Wiedeke Co. See page 267.
Circle T4 on postcard.

ACID PUMPS—Information. A. R. Wilfley & Sons, Inc. See page 178.
Circle T5 on postcard.

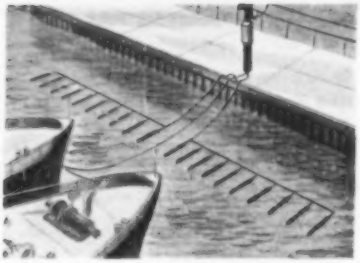
STEAM TURBINES—Data. Worthington Corp. See page 15.
Circle T9 on postcard.

STEAM TRAPS—Bulletin T-1740. Yarnall-Waring Co. See page 67.
Circle U2 on postcard.

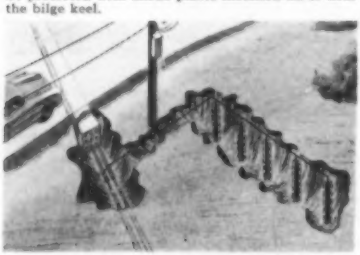
CORROSION

is out to get YOUR critical materials!

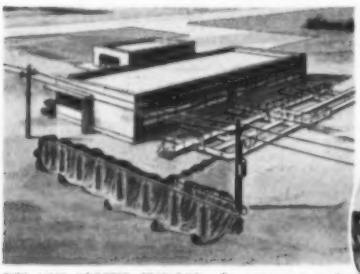
STOP it with NATIONAL TRADE-MARK Graphite Ground Anodes



SHIP HULLS – Inactive ship hulls are effectively and economically protected with remotely located "National" Ground Anodes. Active vessels also can be protected with anode plates mounted on or near the bilge keel.



LEAD-COVERED CABLES – Both telephone and power cables are cathodically protected in many areas with "National" Anodes.



PIPE-LINE BOOSTER STATIONS – In most cases the underground structure of a pipe line booster station, which represents a large monetary investment, can be protected by a single, inexpensive bed of "National" Ground Anodes.

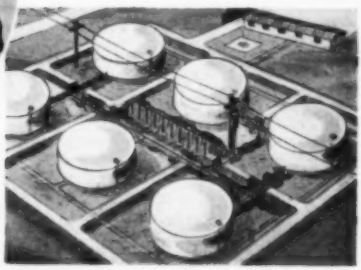
You can do much more than *arrest* corrosion. You can *eliminate it completely* – at a fraction of the cost of maintenance and replacement – with cathodic protection, employing "National" Graphite Ground Anodes.

Proved and widely accepted for the protection of steel and cast-iron pipe lines, cathodic protection is finding new applications every day in the scores of industries that otherwise must continue to pay their share of the terrific toll levied against metal structures by soil, air, water and dissolved minerals.

Here are shown only a few of the ways in which cathodic protection is helping to reduce corrosion damage of critical materials – damage estimated by one authority to be in the neighborhood of $6 *billion* annually.

WRITE FOR CATALOG SECTION S-6510

INDUSTRIAL PLANTS – External corrosion of buried or submerged metal structures can be completely eliminated by the use of "National" Ground Anodes.



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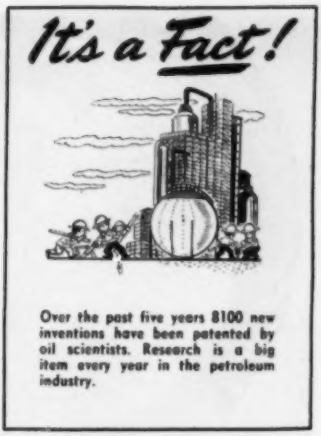
SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.



Over the past five years 8100 new inventions have been patented by oil scientists. Research is a big item every year in the petroleum industry.

Fundamental Physical and Chemical Data

Phase Equilibria in Hydrocarbon Systems n-Butane-Water System in the Two-phase Region, H. H. REAMER, B. H. SAGE, AND W. N. LACEY. *Ind. Eng. Chem.* **44** (1952), pp. 609-15.

The n-butane-water system was investigated in the three-phase region at temperatures above 100° F. and up to 460° F. and at pressures up to 10,000 pounds per square inch. This involved the measurement of the composition of the co-existing phases. In addition, the results of the measurement of the volumetric behavior of a single mixture of water and n-butane are reported. Results are presented in detail in tabular and graphical form. The n-butane-water system in the gas phase of the heterogeneous gas-aqueous liquid region yields a much more complex variation in composition with pressure than is encountered for the methane-water systems or the ethane-water systems under the same conditions. This results apparently from proximity to the three-phase region. The solubility of n-butane in the aqueous phase increases markedly with a rise in temperature above 100° F. for pressures above 750 pounds per square inch. The authors believe that the data will contribute to the understanding of the effect of water on the phase behavior of the lighter components of petroleum. A bibliography of 24 references is included.

Propane-Propylene System. Vapor-Liquid Equilibrium Relationships. G. H. HANSON, R. F. HOGAN, W. T. NELSON, AND M. R. CINES. *Ind. Eng. Chem.* **44** (1952), pp. 604-9.

Reliable vapor-liquid equilibrium data for the system propane-propylene are useful in the design of fractionation equipment for the recovery of high purity propylene. The authors determined the equilibria at three temperatures: 25.5, 82.7 and 134.9° F. These results, together with the five isotherms between 10° and 190° F. previously established by Reamer and Sage, have been correlated. A set of eight smoothed p-x-y curves that are mutually consistent is presented; good agreement was found between the smoothed curves and all the experimental data. In addition to reporting the experimental data, the authors present a correlation method that is an important contribution to the literature in this field. In general, high-pressure vapor-liquid equilibrium data have been correlated empirically. Correlations that are theoretically sound are usually for one isotherm only. The correlation of high-pressure equilibrium data for eight isotherms based on theoretical considerations is a worthwhile development.

Vapor-Liquid Equilibria at Subatmospheric Pressures, System Dodecane-Hexadecene, JOHN R. KEISTLER AND MATTHEW VAN WINKLE. *Ind. Eng. Chem.* **44** (1952), pp. 622-4.

The design of vacuum distillation equipment for the separation of higher molecular weight hydrocarbons requires knowledge of the vapor-liquid equilibria for the systems under consideration. Few such data are available. The results here presented are those of one of a systematic series of studies being conducted for the purpose of evaluating the effect of low pressures on the equilibrium characteristics of heavy hydrocarbons. Data are presented for the system dodecane-hexadecene at pressures of 760, 400, 200, 100, 50, 20 and 10 mm. of mercury absolute pressure. The activity coefficient trend with pressure for this system was too erratic and too close to the ideal value of 1.0 to permit any definite conclusions to be drawn. Within the limits of the accuracy of the data it is indicated that the binary system dodecane-hexadecene follows Raoult's law ideally from 760 to 10 mm. absolute pressure. A bibliography of 6 references is included.

Solubility of Gaseous Paraffins in Methanol and Isopropyl Alcohol. CARL H. KRETSCHMER AND RICHARD WIEBE. *Jour. Am. Chem. Soc.* **74** (1952), pp. 1276-7.

The solubilities of propane, n-butane and isobutane in ethanol were reported in a previous article. The present article reports an extension of the work to the solubilities of these hydrocarbons in methanol and isopropyl alcohol. These were measured at pressures up to one atmosphere and at temperatures between 0° and 50° C. The results are reported as mole fractions of hydrocarbon at a given total pressure. An empirical equation to represent the data is also given. Measurements of the vapor pressure of isopropyl alcohol are included. Partial molal excess free energy, enthalpy and entropy of the hydrocarbons at infinite dilution in the alcohol were calculated, and are discussed in terms of the association of the alcohols.

THESE abstracts are selected from the current literature of science and technology, not including trade journals easily available. Photostatic copies of original articles can be obtained at nominal cost from The Library of Congress, Photoduplication Service, Washington 25, D. C. Complete or limited bibliographies covering special topics by title, by abstract, or in complete manuscript will be prepared and furnished by arrangement with The Leslie Laboratories.

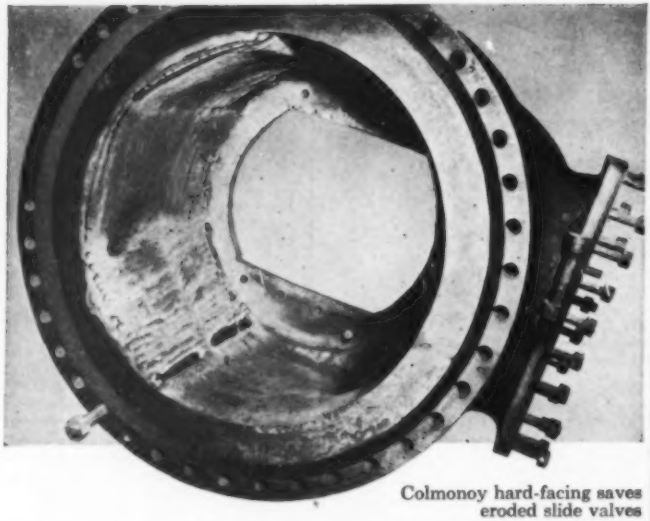
Chemical Composition and Reactions

The Interaction of Ethylene and Deuterium, JOHN TURKEVICH, DONALD O. SCHISSLER, AND PETER IRSA. *J. Phys. & Colloid Chem.* **55** (1951), pp. 1078-84.

The authors report some of the early results from their studies of the interaction of ethylene and deuterium, in which a mass-spectrographic analysis was made of the various deuterioethylenes, deuterioethanes, and the hydrogen deuterium gas during the catalytic conversion of ethylene into ethanes. The apparatus used is described. The reaction vessel was kept at 0° C., and the course of the addition reaction was followed with a McLeod gauge. Deuterium was admitted to the reactor, followed by the ethylene. The reaction was initiated by heating a filament electrically for a measured period of time. The contents of the reaction vessel were allowed to cool before the pressure reading was taken. All the product gases were drawn off through a trap, and both gases and liquids analyzed. It was found that the exchange reaction proceeds more rapidly than the addition reaction, and that the concentration of light ethylene decreases exponentially, while that of substituted ethylenes goes through a maximum before it finally reaches zero. The most surprising result was the discovery of completely light ethane from the reaction of ethylene and deuterium.

Experiments on Compound Formation in Solutions at Low Temperatures. Iodine and Olefins, SIMON FREED AND KENNETH M. SANCIER. *Jour. Am. Chem. Soc.* **74** (1952), pp. 1273-5.

The reaction between iodine and olefins was studied at low temperature. The absorption spectra of solutions of iodine in olefins at temperatures from 77° to 230° K. show the presence of the ultraviolet bands that match those of iodine in aromatic hydrocarbons that have been previously reported. These



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bands are characteristic of 1:1 molecular additions compounds between iodine and hydrocarbons. Such addition compounds are formed by iodine with the olefins propene, *cis*-butene-2, *trans*-butene-2, butadiene-1,3, 2-methylbutadiene-1,3. Cyclopropane also forms such compounds. The addition compounds are formed reversibly. The heats of formation of the addition compounds vary from 200 to 500 calories per mole. At higher temperatures another type of reaction is found, probably the halogenation across the bond. The nature of the addition compounds is discussed.

Catalytic Vapor-Phase Oxidation of Some Four-Carbon Hydrocarbons, R. H. BRETTON, SHEN-WU WAN, AND B. D. DODGE. *Ind. Eng. Chem.* **44** (1952), pp. 594-603.

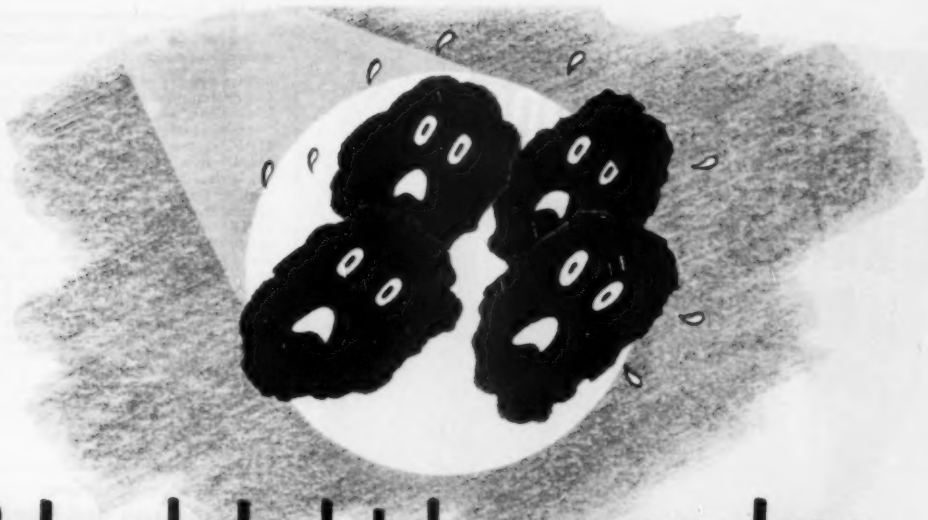
The purpose of the work reported was to furnish information on the air oxidation of four-carbon hydrocarbons, using a few selected catalysts. The hydrocarbons were n-butane, 1-butene and 2-butene, isobutylene, and 1,3-butadiene. Several silver and silver oxide catalysts and one vanadium pentoxide catalyst were studied. Butane proved to be quite resistant to oxidation, and for this reason only a few runs were made with this hydrocarbon. When using the silver oxide catalysts only traces of intermediate products were found when the four-carbon hydrocarbons were passed over the catalyst to be oxidized. When vanadium pentoxide catalyst is used appreciable amounts of intermediate products are formed. Butadiene yields maleic acid, formaldehyde, and glyoxal. 1-butene and 2-butene yield these same products and also acetaldehyde, acetic acid, methyl, and methyl vinyl ketone. The oxidation of isobutylene leads to acetic acid, alpha-methylacrolein, and formaldehyde. The yields and conversions at various air-to-hydrocarbon ratios, and at various temperatures and contact times, are given and the results are discussed. A bibliography of 24 references is included.

Coordination of Silver Ion with Unsaturated Compounds. V. Ethylene and Propene, KENNETH N. TRUEBLOOD AND H. J. LUCAS. *Jour. Am. Chem. Soc.* **74** (1952), pp. 1338-9.

Compound formation between ethylene and propylene and aqueous silver ion was studied by a distribution method. It was found that the constants for the formation of a 1:1 complex are roughly the same for these two olefins. No appreciable quantity of diolefin complex is formed by either hydrocarbon in the concentration range studied, but there is evidence for di-silver complexes at high concentrations of silver ion.

Synthesis and Characterization of Ethylene/Carbon Monoxide Copolymers, A New Class of Polyketones, M. M. BRUBAKER, D. D. COFFMAN AND H. H. HOEHN. *Jour. Am. Chem. Soc.* **74** (1952), pp. 1509-15.

Carbon monoxide copolymerizes with ethylene to form a family of polyketones. The investigation reported concerns the synthesis and properties of these polyketones, which contain CO and CH_2CH_2 groups, display the chemical reactivity characteristic of carbonyl compounds, and range in properties from liquids to



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Science and Technology

solid polymers of high molecular weight. Confirmation of the polyketone structure is furnished by the formation of derivatives characteristic of typical ketones. Hydrogenation of the polyketones yields polyalcohols without cleavage of the long chain. Reaction with hydroxylamine and with hydrogen cyanide gives the corresponding oximes and cyanohydrins, respectively. Oxidation by nitric acid gives polymethylene dicarboxylic acids ranging from glutaric acid through sebacic acid. The polyketones of approximately 400 molecular weight are mobile liquids. As the molecular weight is increased to 1000-3000, the copolymers range from viscous liquids to crystalline waxes. The crystallinity of a typical wax-like polyketone closely resembles that of the microcrystalline petroleum waxes. The crystal size of the polyketones is frequently smaller than that of a typical microcrystalline petroleum wax.

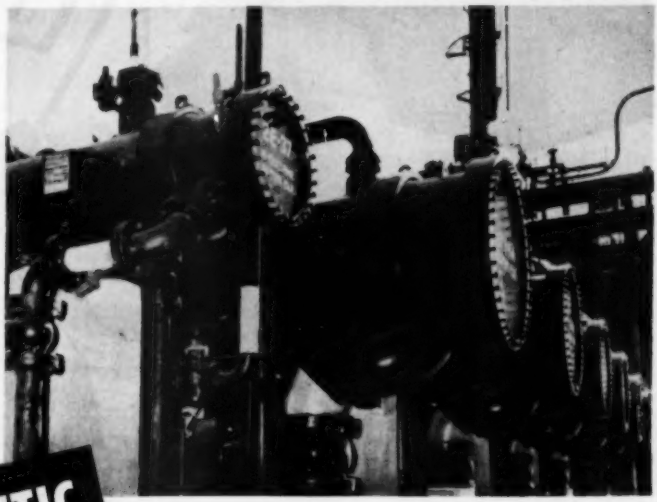
Manufacture: Processes and Plant

Fluid Flow Through Packed Columns, SABRI ERGUN. *Chem. Eng. Progress* **48** (1952), pp. 89-94.

The author reviews the existing information on the flow of fluids through beds of granular solids. It has been found that pressure losses include viscous energy losses and kinetic energy losses. A comprehensive equation is given that is applicable to all types of flow. The equation was examined from the point of view of its dependence upon flow rate, properties of fluids, fractional void volume, orientation, size, shape, and surface of the granular solids. The author presents a new concept of the friction factor which represents the ratio of pressure drop to the viscous energy term. This, he believes should have advantages over the conventional type of friction factor. A bibliography of 27 references is included.

The Correlation of Slot-Opening with Flow Rate for Air Bubbling into Water, C. A. CROSS AND H. RYDER. *Jour. of Applied Science* **2** (1952), pp. 51-60.

The authors investigated the flow of air through slots with particular reference to the design of bubblet caps for fractionating columns. They refer to the work of Rogers and Thiele in 1934, noting that their results gave adequate agreement with experimental data for a wide variety of vapors and liquids in the range of 0.1 to 1.0 inch of slot opening. However when extrapolated to 2 in. slot opening or for smaller openings than those included in the minimum flow point, the results can lead to gross inaccuracies. The work done was directed to the elimination of these uncertainties. Some 300 determinations were made at air rates between 0.01 and 800 cubic feet per minute for one rectangular and one triangular slot. A few measurements were made with slots of other dimensions. All measurements are shown to fit the simple hydrodynamic theory when this is modified to take account of surface tension effects. The new theory requires that below a critical air rate the slot opening should be determined by surface tension effects alone, whereas above this rate the original hydrody-



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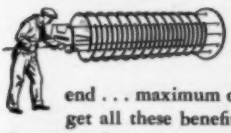

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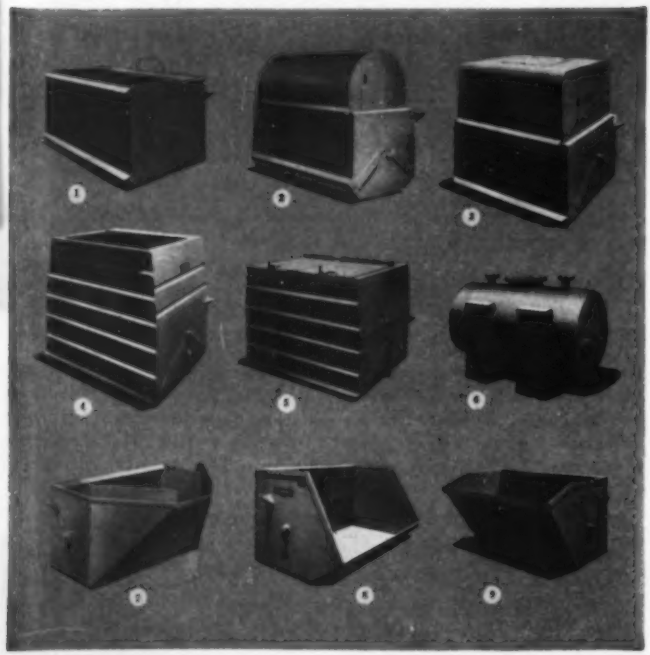

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At left are a few standard containers for general requirements—1—Drop Bottom Container built up to 10 cu. yd. capacity to handle heavy materials. 2—Apartment Type for bulk trash and rubbish with sump bottom for handling moist materials. 3—Universal Type available with top and end doors. 4—Drop Bottom Pressed Steel Type for lighter service. 5—Drop Bottom Pressed Steel Type with counterbalanced spring lids. 6—Tank Type Container meeting A.S.M.E. specifications. Capacities up to 1,200 gallons. 7—Tilt Type with Converged Lip for handling fine aggregate, wet or fluid materials. 8—Skip Type with Lip to assist in holding certain types of loaded materials in place. 9—Tilt Type for handling heavy materials. Built water-tight.

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More efficient and lower cost materials handling in your plant may be simply a matter of getting the probing minds of your engineers and ours together. Our files contain hundreds of inquiring letters that ultimately resulted in savings of thousands of dollars annually in every conceivable type of manufacturing plant. A discussion with our engineers might develop the same results for you. If advisable, they will be glad to make, without obligation on your part, a proper survey to determine just what equipment you may need. The Dempster-Dumpster System is manufactured exclusively by Dempster Brothers, Inc.

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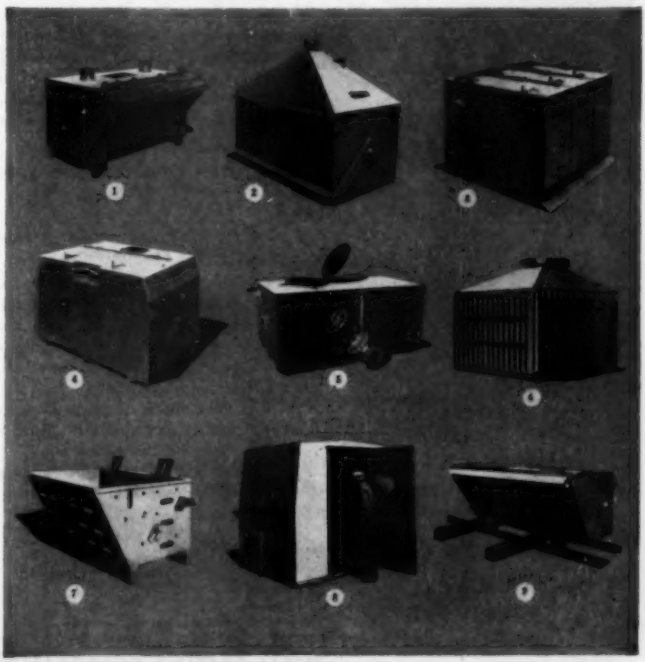
At right are a few containers built for special requirements— 1—Five cu. yd. container with swivel casters for handling waste blast sand. 2—Three cu. yd. Dust Collector Type equipped with gaskets. 3—Multi-Karry Container equipped with three 2 cu. yd. steel boxes with casters and lids. 4—Six cu. yd. drop bottom container with two spring-hinged lids and special loading opening in top. 5—Rectangular Tank Type Container with gate valve and gasketed Lid. 6—Chlorinator Ash Container designed for handling hot residue approximately 1500° F. 7—Tilt Type Container built for cast linings for handling hot materials. 8—One of several special "Tool and Equipment" Type Containers. 9—One of several types of special built containers equipped with ball bearing trucks.



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namic equations apply. Values found for the constants of these equations are significantly different from those proposed by previous workers. The exponents of h (the slot opening) now correspond with the theoretical values to within the limits of experimental accuracy.

Limiting Flow and Holdup in a Spray Extraction Column, G. W. Minard and A. I. Johnson. *Chem. Eng. Progress* **48** (1952), pp. 62-74.

The simplest countercurrent extraction tower is the spray tower. For a given continuous phase rate, as the dispersed phase rate is increased, the number of drops increases. The volume fraction of the column occupied by this dispersed phase is defined as the holdup H. Since holdup and drop size govern contact area, both enter into the extraction efficiency of the tower. The limiting-flow condition corresponding to a given continuous phase rate is that dispersed phase rate at which not all the phase from the spray nozzle will pass through the tower. A study of this limiting condition is presented in the paper. The authors derive equations limiting the flow rates of the two phases at flooding and holdup at flooding. The results from the tower study are expressed graphically to show the usefulness of these equations and a correlation is developed and proposed to express limiting flow in a tower. The limiting flow data were also correlated by the method of Elgin and Foust and the two correlations are compared. A bibliography of 12 references is included.

Applications of Fluid Mechanics and Similitude to Scale-up Problems. Part II, J. H. Rushton. *Chem. Eng. Progress* **48** (1952), pp. 95-102.

The author briefly reviews the principles of dynamic similitude. Fundamental concepts of fluid mechanics are used to develop relations between fluid motion, equipment size, and fluid properties. A general procedure is given through the use of which requirements for dynamic similitude for any flowing system can be determined. These principles can be applied in pilot plant models to obtain scale-up data for operations involving resistance to fluid flow, discharge of liquids from tanks, blending of liquids, control of forced vortexes, dissolving of solids through mixing, and the absorption and desorption of gases in moving liquids. It is suggested that the same principles can be applied to any type of operation involving mass transfer in a liquid, and to other flow operations such as fluidized systems and suspensions. A bibliography of 21 references is included.

Cogelled Chromia-Alumina Catalyst for Naphtha Reforming. Evaluation of Hydrocarbon Types and Naphthas, E. C. Hughes, H. M. Stine, H. A. Strecker, S. C. Eastwood, C. L. Gutzeit, W. A. Stover, and S. J. Wantuck. *Ind. Eng. Chem.* **44** (1952), pp. 572-5.

The development of a chromia-alumina catalyst for naphtha reforming was described in a previous paper as applied to a single naphtha. Chromia-alumina catalyst has been developed into a cogelled bead form, mechanically strong and resistant to wear. In the course of the work in which the catalyst was studied, straight-run and coker naphthas

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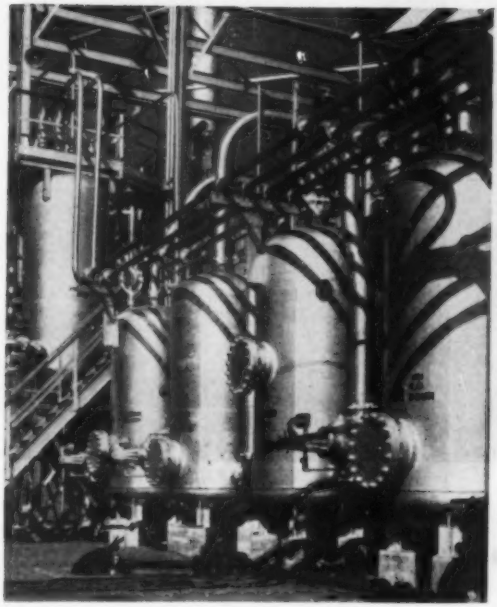

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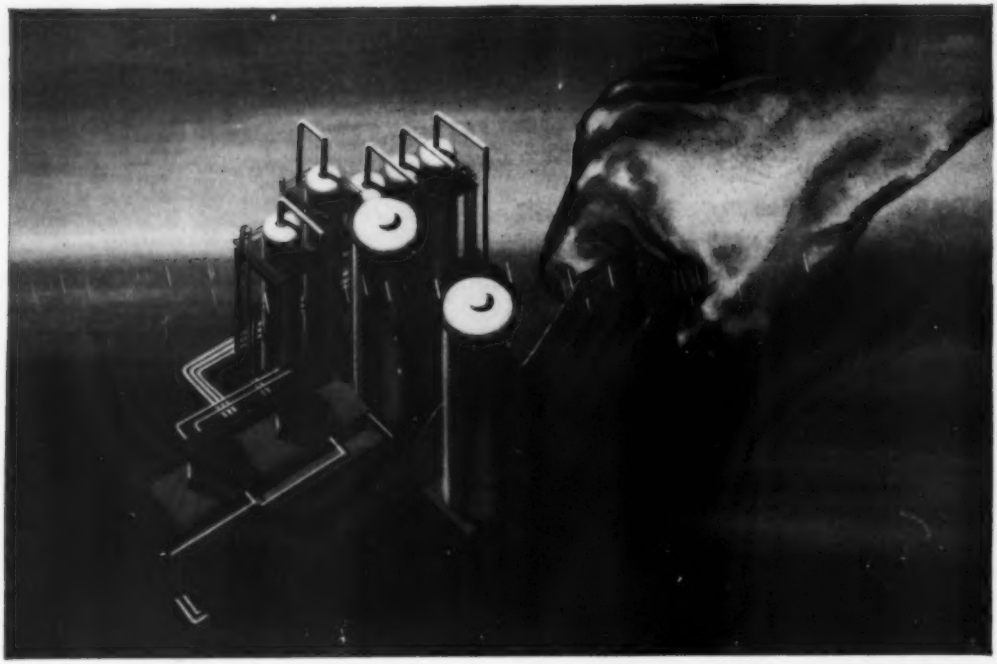

How To Bolt Down Profits In New Production Planning

Has a tough operating problem threatened your output schedules? Here's how one producer licked his problem before it started.

For a new process this refinery required economical heating, under vacuum, of highly corrosive crude that was to be pumped into a fractionator for further processing.

SOLUTION: Crude oil feed tanks of stainless-clad steel, vertical type, externally braced. Heat is provided by an internal steam coil of solid stainless steel. Vacuum operation is withstood successfully by clad steel tank design. Flued openings and manholes provide for easy inspection and maintenance. Inner stainless surfaces resist corrosion; carbon steel backing and steel stiffening rings insure rigidity and strength with maximum economy. Result: economical heating of crude oil to proper temperature. Corrosion problem eliminated by equipment with low first-cost and long service life. Maintenance costs reduced to a minimum.

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from many crudes were tested over a range of operating conditions. Substantial differences were noted between naphthas from various sources. From the results of the work, relationships are developed between naphtha compositions and the results obtained. Experiments were conducted on the preparation of motor gasoline, aviation blending stocks and pure aromatic compounds, using naphthas from several typical crude oils and from mixed straight-run and from cracked naphthas. Variations of as much as 15 volume percent at constant octane number were found. Reformed products showed good stability and were practically completely desulfurized. The variation in yield from the different naphthas was found to correlate with the Watson-Nelson K factor, paraffinic naphthas giving the lowest yields. This correlation makes it possible to select naphthas for optimum yields. A bibliography of 12 references is included.

An American Fischer-Tropsch Plant, M. L. KASTENS, L. L. HIRST AND R. G. DRESSLER. *Ind. Eng. Chem.* **44** (1952), pp. 450-66.

The article is a staff report by Industrial and Engineering Chemistry in which the history of the production of liquid fuels from non-petroleum materials is briefly reviewed and followed by a description of the activities of the U. S. Bureau of Mines in this field of work in this country. The conversion of coal to liquid fuel can be effected either by hydrogenation of the coal itself or by gasification followed by synthesis. Both the procedures are under study by the Bureau of Mines. The present article has to do particularly with the gasification and synthesis process. The gasification of the coal, purification of the gas, and synthesis of liquid materials from the gas are described in some detail. A description of various alternative processes is also included. Finally, materials of construction and the economics of the operation as a whole are briefly considered. A bibliography of 47 references is appended.

Hydrogenation of Shale Oil, W. M. SMITH, T. C. LANDRUM, AND G. E. PHILLIPS. *Ind. Eng. Chem.* **44** (1952), pp. 586-9.

The authors describe one method of attack on the problem of preparing saleable refined products from crude shale oil. Shale oil differs from crude petroleum in that it is highly unsaturated and has a high content of nitrogen compounds. Although it was shown that the pour point of crude shale oil could be reduced from 90° F. to below —30° F. with little formation of light ends by means of light thermal cracking, the hydrogenation work was conducted using the crude shale oil without visbreaking because it was believed that the critical part of the process as a whole is the satisfactory removal of sulphur and nitrogen from the crude shale oil. Hydrogenation of the crude shale oil at 3000 pounds per square inch gage over a fixed-bed catalyst consisting of nickel sulfide plus tungsten sulfide was found to give satisfactory results and catalyst life with a minimum production of gasoline and low boiling components. Nitrogen was 95 percent removed with a hydrogen consumption of 1800 cubic feet per barrel of shale oil. The yield of hy-

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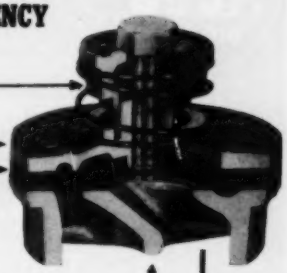

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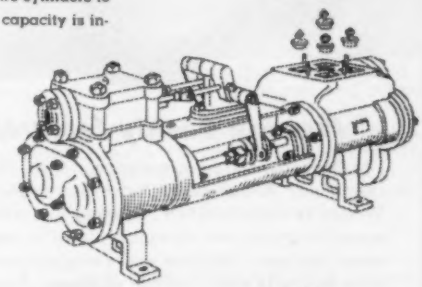

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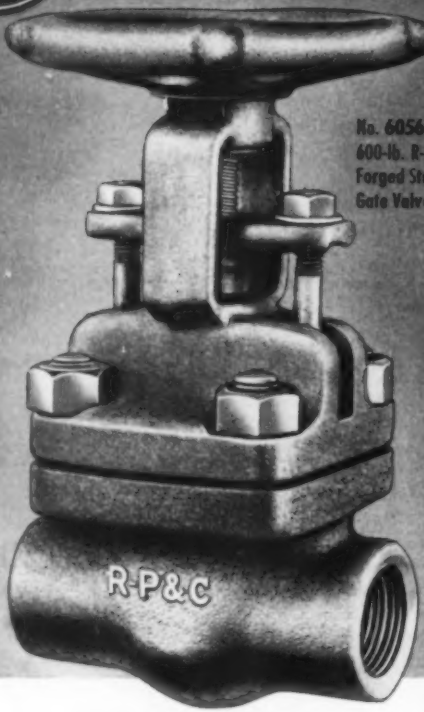

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drogenated oil was over 100 volume percent in all instances. The improvement in color and odor was marked. A light acid treatment resulted in additional color stability with little loss in yield. It is believed that the hydrogenation process may serve as a means of producing shale oil as a synthetic crude oil which can be treated by conventional processes now used for petroleum oils.

Petroleum Refineries, N. J. GOTHARD AND J. A. FOWLER. *Ind. Eng. Chem.* **44** (1952), pp. 503-7.

The article dealing with waste from petroleum refineries is one of a series of articles in a symposium presented before the Division of Water Sewage and Sanitation Chemistry of the American Chemical Society. The pollution abatement program at the Sinclair Refining Company at East Chicago, Ind., is described, and it is the purpose of the paper to discuss the results obtained through putting the program into effect. The program involved 4 basic features, first, separation of sanitary sewage from other refinery waste, second, reduction of over-all volume of refinery wastes to a minimum, primarily by use of cooling towers for recycling cooling water, third, construction of A.P.I. oil separator of adequate capacity, fourth, treatment of heavily polluted wastes at their source before they were allowed to enter the refinery sewer. The article contains diagrams of special equipment used and data showing the results of tests on effluent materials.

The Resistance of Fire-Fighting Foams to Destruction by Radiant Heat, R. J. FRENCH. *Jour. of Applied Chem.* **2** (1952), pp. 60-4.

An essential property of a fire-fighting foam is the ability to remain stable when subjected to intensive radiation. The author describes experiments to determine an index of the resistance of fire-fighting foams to radiant heat, and describes the development of an apparatus to make the measurements. Experiments were made to determine the manner in which the resistance of the foam to radiant heat is influenced by the intensity of the radiation and by the expansion factor and ultimate shear strength of the foam. It is shown that maximum resistance to radiant heat is obtained from foam of low expansion and high shear strength and that the heat-resistance index depends on the water content of the foam over the normal range of expansion factors. In practice there may be several other considerations that will influence the selection of foam properties. Foams of high ultimate shear strength and consequent low fluidity would be undesirable, since the rate at which they could cover the liquid surface would be low and it might be impossible to achieve complete coverage. It may be better to use a moderately high value of the expansion factor because the greater volume of foam produced from a given quantity of water may more than offset the lower heat resistance of the highly expanded foam. Taking all factors into consideration it seems probable that there will be optimum values for the expansion and shear strength of foam produced from a particular compound. In other words, if fire-fighting efficiency were plotted against the expansion fac-

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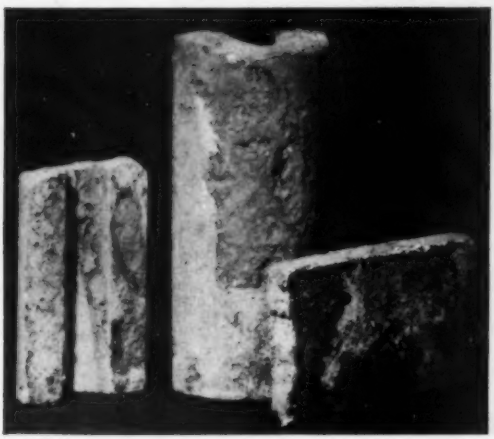
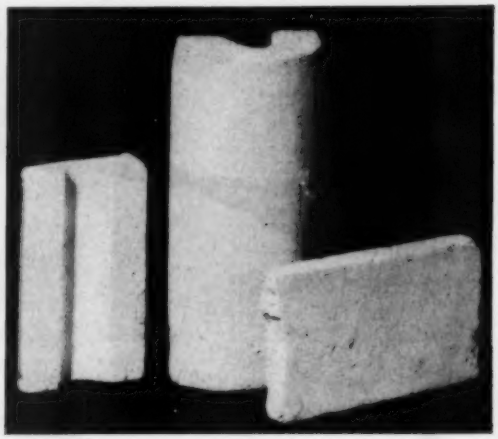


WATER SOAKED AND CAKED WITH MUD, these three pieces of Kaylo Heat Insulation were found partially buried in the Kansas City, Missouri, warehouse of Procter & Gamble after nearly two weeks of Missouri River flood water had receded. The unretouched photograph above shows the wet and mud covered pieces as they looked on arrival at the laboratories in Toledo, Ohio after shipment in a loosely-packed carton.



THE SAME THREE PIECES are shown in this unretouched photograph after they were cleaned by holding them under a water faucet and rubbing by hand, then dried with an electric fan. These pieces are still usable—*proof* of Kaylo Heat Insulation's resistance to water damage. Other Kaylo Heat Insulation, already installed at this plant, was under water during the flood, yet is still in place and performing efficiently.

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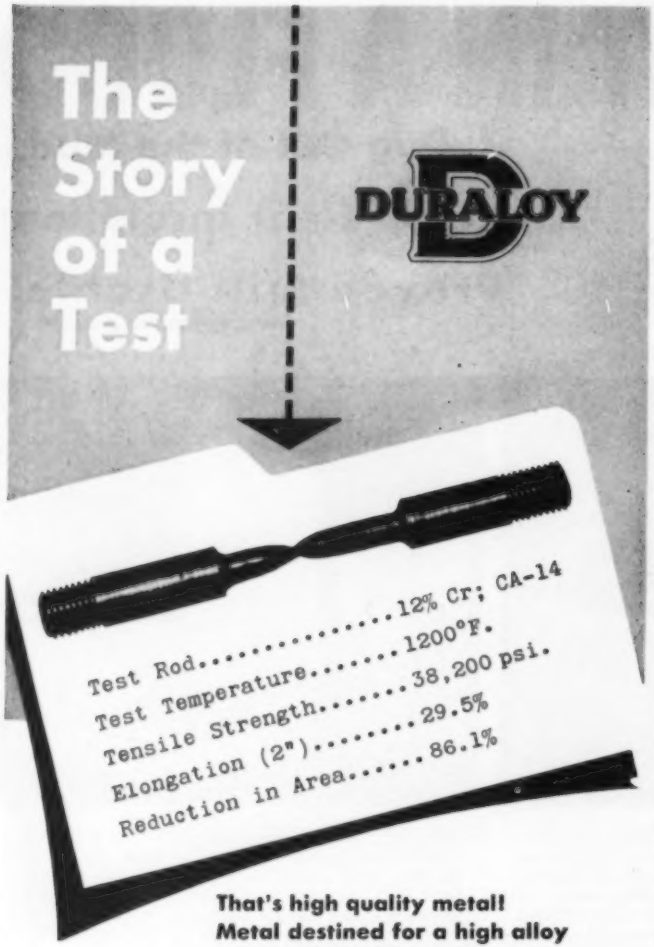

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Science and Technology

tor and shear strength of the foam, the curves would have maxima.

Products: Properties, Utilization and Analysis

Phthalocyanine Lubricating Greases, VINCENT G. FITZSIMMONS, ROBERT L. MERKER, AND CURTIS R. SINGLETERRY. *Ind. Eng. Chem.* **44** (1952), pp. 556-63.

The need for high temperature greases useable above 150° C., or, more particularly, in electric motors at 200° C. or above, has become increasingly urgent. Soap used as a gelling agent deteriorates rapidly at these temperatures. The high melting point, chemical inertness, and high thermal stability of the phthalocyanine pigments, together with the exceedingly fine state of subdivision in which they are available, make them an interesting type of gelling agent for high temperature greases. These pigments form greases with petroleum oils, silicones, aliphatic diesters, polyalkylene glycol ethers, and flurohydrocarbons. These greases contain 80 percent or more of liquid by volume, and maintain their structure at temperatures above 300° C. They are resistant to water, and less susceptible to oxidation than soap greases. The phthalocyanine pigments are not abrasive. Greases of this new type have lubricated ball bearings for 10,000 hours at 80° C. and for as long as 900 hours at 220° C. The development of greases that can be used at 200° C. permits the redesign of electric motors, with large economies in space, weight, and critical materials.

Petroleum, HARRY LEVIN. *Analytical Chem.* **24** (1952), pp. 266-70.

The article is one included in the fourth analytical review of Analytical Chemistry. It covers the literature for approxi-

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The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

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p-Sexiphenyl
Hexabromocyclohexane
Hexadiine-1,5
Methyl vinyl sulfone
Cyclooctanone
1,2-Benzenedithiol
Dimethyl arsine
3,5-Dihydroxy-2-naphthoic acid
N-Methyl acridone
8-Mercaptoquinoline
Maleic dialdehyde
Hexa-(p-biphenyl) ethane

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Above explosion at Perth Amboy June, 1949 — Another at Chicago February 1950

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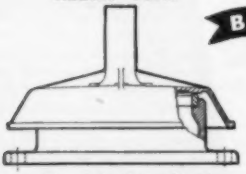

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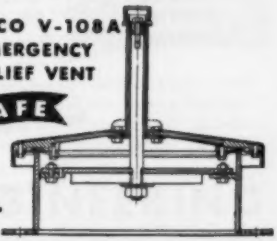

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5 Cr, ½ Mo
5 Cr, ½ Mo, 1½ Si
5 Cr, ½ Mo, Ti
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mately one year from the date of the previous annual review. The subjects covered are crude oil, gas, gasoline, kerosine and heavier fuels, lubricating oil, asphalt, specialties, pollution, sulfur and its compounds, various other elements, catalysts and a number of miscellaneous items.

Theoretical Basis of the Bouguer-Beer Law of Radiation Absorption. FREDERICK C. STRONG. *Analytical Chem.* **24** (1952), pp. 338-42.

The author has observed that the relationship of absorption of radiation to thickness of absorbing material and concentration of an absorbing component is customarily presented as the result of an experiment. In view of his desire to see a derivation based on theory only, the author developed and presents such a derivation, based only upon the modern theories of matter and energy. The radiant power of a beam is considered as the number of photons passing per unit time and the process of absorption is conceived as the capture of photons by molecules or ions, the probability of capture is related to a ratio of areas in a given element of material. This is integrated over three dimensions for identical photons, that is monochromatic radiation, to yield the familiar absorption law. The general case of a beam with a continuous distribution of wave lengths is obtained by further integration and the results given in several forms. Since some of the equations are difficult to comprehend, the author presents graphical interpretations, followed by analysis of possible methods of employing the law in practical work. The causes of apparent deviation are considered and discussed. Both the theoretical derivation and the graphical interpretations of the absorption law will make it more intelligible and fruitful in its application to analytical work.

Ethyl Announces Ignition Improver For Diesel Fuels

The Ethyl Corporation has extensive service tests underway on a new ignition improver for diesel fuel which will make it possible for refiners to improve the cetane number of middle distillates. The compound consists of a mixture of primary amyl nitrates, which is blended into the finished fuel. The performance tests being undertaken by the oil industry follow extensive investigations already in progress. These include large-scale service tests by the U. S. Navy, over-the-road tests in diesel trucks, and full-scale tests in the Ethyl Research laboratories at Detroit. Commercial production awaits the outcome of the service tests.

Nuclear Laboratories Set-Up To Develop Atomic Power

The establishment of the Walter Kidde Nuclean Laboratories, Inc., with the primary objective of developing commercial atomic power has been announced, and is the first privately-financed laboratory dedicated to research in nuclear power. It is an associate of other Kidde enterprises, which include Walter Kidde & Company, Inc. The

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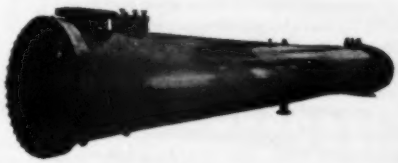

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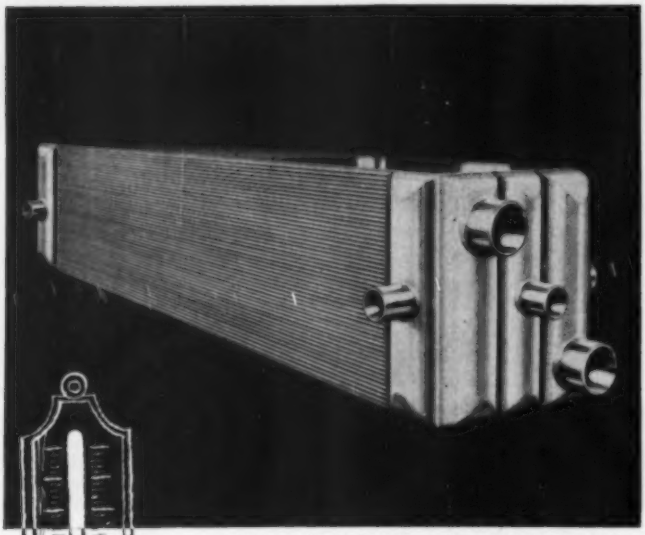

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Oil Chemists Schedule Short Course at Rutgers

The American Oil Chemists Society Short Course to be held at Rutgers University in July, will feature industrial trips. Plants to be visited are the Lever Brothers, Edgewater, N. J.; Howard Smith Company, Port Newark, N. J.; Wobrun Chemical Corporation, Kearny, N. J.; and Colgate-Palmolive-Peet Company, Jersey City, N. J.

Dr. Foster Dee Snell is general chairman of the meeting which will be held July 7-11.

ASTM Announces Change of 1953 Annual Meeting Date

The American Society for Testing Metals has announced that it has changed the date of its annual meeting for 1953 from June 22-26 to June 29-July 3. As previously announced, the meeting will be held in Atlantic City, N. J. This change has been made at the request of the Departments of Commerce and State and specifically of the United States National Commission of the Pan American Railway Congress Association.

U. S. Rubber President Requests Government Sale

H. E. Humphreys, Jr., president of the United States Rubber Company, has recommended that the government immediately offer private industry an opportunity to lease all government-owned GR-S synthetic rubber plants, including feedstock facilities, as a step toward eventual sale of the plants to private operators. Humphreys also recommended that the Rubber Act of 1950, which expires June 30, 1952, be amended to give the government authority to sell the plants to qualified operators and that it be extended for a maximum of one year to June 30, 1953, at which time the offer to sell would become subject to immediate acceptance.

"The way to start is to lease the plants to private industry at once," he said. "The present law permits leasing. I can see no reason for further delay. I believe that most rubber manufacturers would prefer a lease arrangement because it would give them an opportunity to ascertain operating costs under private management." He said this information is necessary to enable the government and prospective buyers to determine accurately a plant's actual value.

Richard Huey, Deep Rock, Opens Consulting Office

Richard K. Huey, long time production vice president of Deep Rock Oil Corporation, has opened a private petroleum consulting office in Tulsa and in addition will operate as a gas company owner in the Atlas Life Building. The Cimarron Gas Company will operate a gas transmission system in Payne and Lincoln Counties, Okla.

ALUMINUM MONEL* BRASS STEEL

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INCONEL* STAINLESS STEEL NICKEL* COPPER

Sheet, Plate, Tube, Pipe, Wire, Rod and Bar, Extrusions, Structural Shapes .. and the following INDUSTRIAL PRODUCTS: Fasteners, Tube Fittings, Pipe Fittings, Valves, Silver Brazing Alloy, Welding Material, Solder, Castings, Tube Expander Equipment, Liquid Plastic Protective Coating, Metallic Caulking Compound, Aluminum Metal Trim, Waterproof Barriers, Nails, Handrail Fittings, Low Melting Alloys, Aluminum Jacketing, Wire Cloth and Rope, and "O" Rings.

Precision Equipment for Shearing and Slitting.

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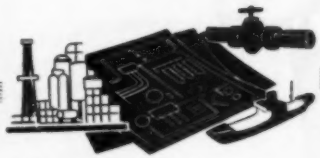
Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by DR. HEINZ HEINEMANN

(From the Official Gazette, February 26, and March 4, 11, 18, 25, 1952)



REFINING

U.S.P. 2,586,777. Method of Separating Olefins from Hydrocarbon Mixtures. G. R. Bond, Jr., to Houdry Process Corporation.

Olefin containing crude liquid hydrocarbon fractions is treated with nitrogen trioxide at room temperature. The resulting precipitate is removed. The residual liquid fraction is treated with nitrogen tetroxide in a corresponding manner. The resulting fraction is steam distilled and washed with alkali. A substantially olefin-free product is obtained. Olefins can also be removed from liquid hydrocarbon fractions boiling in the range up to 600°F. by treatment with N_2O_4 at a temperature of 70-100°F. in a similar manner.

U.S.P. 2,586,889. Separation of Straight-Chain from Branched-Chain Hydrocarbons. H. G. Vesterdal and W. A. Konrad to Standard Oil Development Company.

A mixture of a normally liquid straight-chain hydrocarbon with one or more normally liquid branched-chain aliphatic hydrocarbons or cyclic hydrocarbons is contacted with an activated carbon. This activated carbon is prepared by treating acid sludge coke with steam at a temperature of 1350-1500°F. until a yield of 70-90 percent by weight of activated carbon based on the weight of the acid sludge coke is obtained. The straight-chain hydrocarbon is preferentially adsorbed by the activated carbon and is thus separated from the other hydrocarbons.

U.S.P. 2,587,595. Separation of Hydrogen Halides from Olefinically Unsaturated Compounds. H. A. Cheney and J. H. Raley to Shell Development Company.

A mixture of olefins and Hcl is continuously treated in a fractionating column in the liquid state and in the presence of a small amount of a thiol in such a manner that Hcl is distilled off at the top while olefin is withdrawn at the bottom of the column. Interaction of the components of the mixture is greatly reduced by the additive.

U.S.P. 2,587,640. Recovery of Acid Values from Petroleum Refining Sulfuric Acid Sludges. H. Miley to L. Sonneborn Sons, Inc.

A stream of sulfuric acid sludge from petroleum refining is continuously passed into a decomposition zone while a superheated gas is continuously passed into this zone in heat exchange relation with the sludge. The gas heated to a temperature above 500°F. contains at least 75 percent by volume of steam. The temperature is maintained sufficiently high and the contact period between sludge and gas sufficiently long to coke the major portion of the hydrocarbons. The gaseous decomposition products formed are subjected to water condensation, and SO_2 gas of high purity is recovered therefrom.

U.S.P. 2,587,643. Deasphalting Mixtures of Hydrocarbons. H. C. Myers to Socony-Vacuum Oil Company, Inc.

An asphalt-containing fluid charge stock is contacted with an agent consisting of 1-20 percent by volume of an organic carbonate and the balance major deasphalting agent, such as propane, at a temperature above that at which paraffin wax is insoluble in the mixture of charge stock and agent to about 206°F. A deasphalted oil having a Conradson carbon residue of 0.4-6 percent by weight is obtained in greater yield than without the addition of the organic carbonate.

U.S.P. 2,587,689. Separation of Acetylene from Gaseous Hydrocarbon Mixtures. E. O. Box, Jr., to Phillips Petroleum Company.

A mixture of acetylene and gaseous paraffins is scrubbed with liquid acetic anhydride in the absence of water. The acetylene is preferentially dissolved therein while more saturated hydrocarbons remain undissolved.

U.S.P. 2,588,056. Separation of Propene and Propane by Extractive Distillation. J. W. Teter and E. W. Shand to Sinclair Refining Company.

A propene-propane mixture is extractively distilled with a less volatile multicomponent solvent comprising in about equal volume proportions acetonitrile as a first component and acrylonitrile or monochloroacetonitrile as a second component. A vapor fraction rich in propane is separated from a liquid fraction comprising propene and solvent.

U.S.P. 2,588,063. Separation of Propene and Propane by Extractive Distillation. S. J. Wayo, J. W. Teter and E. W. Shand to Sinclair Refining Company.

The process of this patent is closely related to that of U.S.P. 2,588,056. The first solvent component here is formed by 11.4-27.8 percent by volume of acetamide or propionamide, and the second component by 88.6-72.2 percent of acetonitrile or propionitrile.

U.S.P. 2,588,296. Gas Treatment and Apparatus Therefor. G. F. Russell, Jr., to Aluminum Company of America.

A system is claimed for receiving, handling, and treating moisture bearing gaseous hydrocarbon fluid issuing, under relatively high pressure, from a well.

U.S.P. 2,588,305. Process for Distilling Hydrocarbons. H. E. Sullenger to Phillips Petroleum Company.

A liquid feed stock of a multicomponent hydrocarbon mixture is separated into a high boiling and a low boiling fraction by injecting it in uniform flow and at uniform temperature into a fractionating zone and withdrawing a major portion of the higher boiling residual product. This portion is subjected to indirect heat exchange with the liquid feed stock. The remaining portion of the high boiling residue is withdrawn at such a rate that the level of accumulated residue in the lower section of the fractionating zone is maintained constant. The two residual fractions are finally combined.

U.S.P. 2,588,346. Refining Gasoline and Petroleum Oils with Aqueous Antimony Trichloride. George R. Bond, Jr., to Houdry Process Corporation.

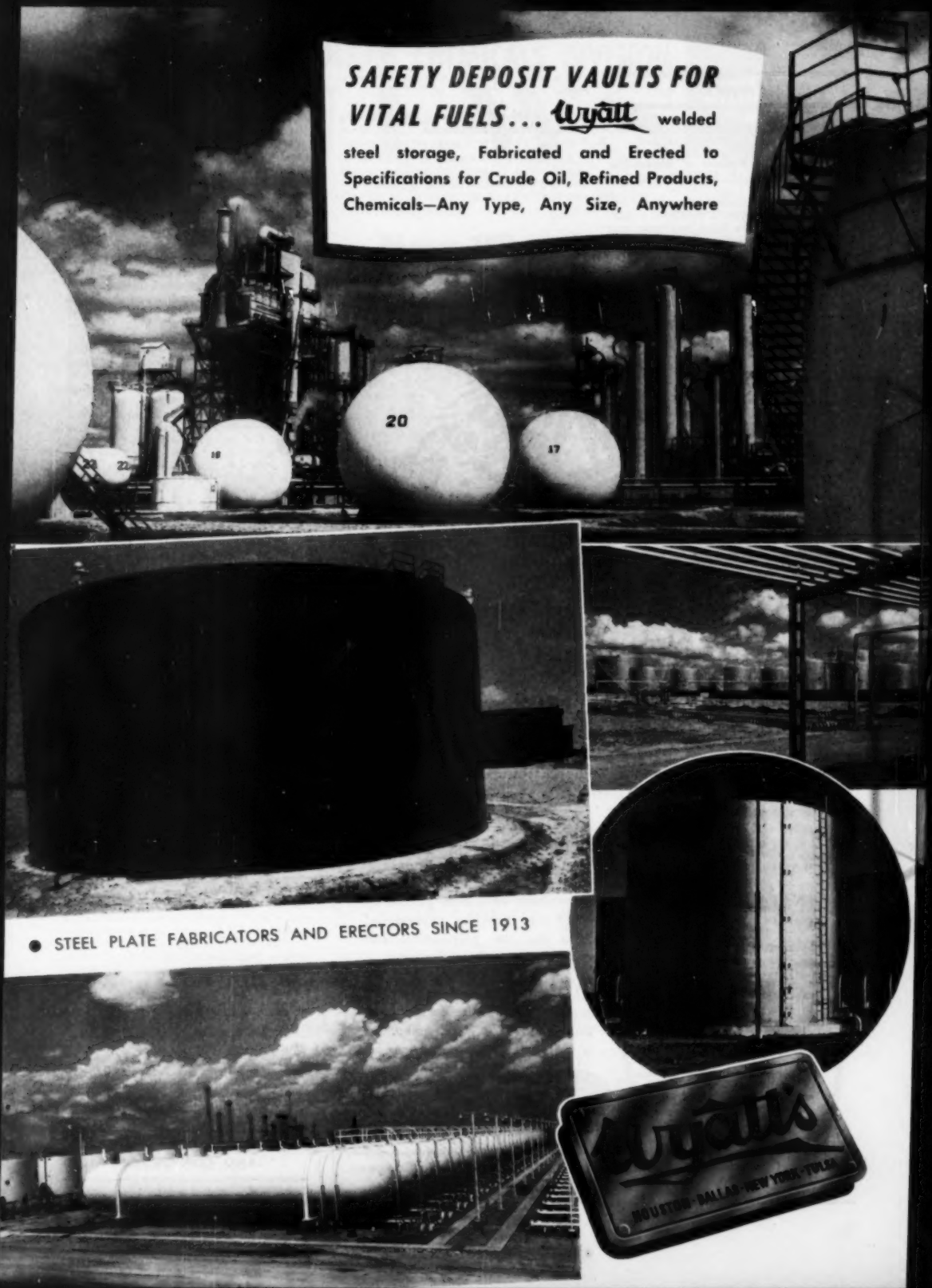
Liquid petroleum hydrocarbons are treated for color removal, sweetening, and stability improvement with an aqueous solution of antimony trichloride. At least 0.1 percent and up to 10 percent of saturated $SbCl_3$ solution are used per volume of liquid hydrocarbon.

U.S.P. 2,588,506. Extractive Fractionation Process. L. C. Fetterly to Shell Development Company.

A process for extracting hydrocarbons by complex formation with urea or thiourea is described in which the raffinate from the extraction is fractionated with or without a preceeding treatment, such as isomerization, and a fraction rich in extractable material is recycled to the extraction step.

U.S.P. 2,588,602. Fractionation of Organic Compounds by Adduct Formation. C. E. Adams and R. A. Dinerstein to Standard Oil Company of Indiana.

A mixture of at least two urea-adduct forming straight-chain hydrocarbons of different mole weights is contacted with an urea solvent and an amount of urea sufficient to react with all the adduct-forming hydrocarbons of highest mole weight, but insufficient to react with all adduct-forming hydrocarbons. The re-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Patents

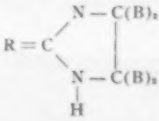
sulting urea adduct of the hydrocarbon of highest mole weight is separated.

U.S.P. 2,588,794. Method of Separating Oil from Water. P. D. Barton to Sun Oil Company.

An oil-in-water suspension, as, for example, obtained from a catalytic cracking operation of the fixed bed type, and containing a relatively minute amount (less than 200 p.p.m.) of petroleum distillate oil, is passed through a bed of glass wool having a fiber diameter less than 0.001 inch. The rate of flow is maintained sufficiently low to affect coalescence of the oil particles. An oil layer and a water layer are formed and separated.

U.S.P. 2,589,198. Process for Breaking Oil-in-Water Emulsions. L. T. Monson to Petrolite Corporation, Limited.

An oil-in-water emulsion is broken by means of a reagent comprising a substituted imidazoline of the formula:



or compounds of this type wherein the H atom is substituted by R or DR, and wherein B is hydrogen or an alkyl radical with less than 8 C atoms, D is a divalent amino or non-amino organic radical with less than 25 C atoms, and R is hydrogen, an aliphatic, or a cycloaliphatic radical.

U.S.P. 2,589,199, U.S.P. 2,589,201. Process for Breaking Emulsions of the Oil-in-Water Class. L. T. Monson to Petrolite Corporation, Limited.

The processes according to these patents are related to that of U.S.P. 2,589,198. Another type of demulsifier is here employed which is obtained by reacting certain poly-halogenated non-ionized organic compounds and a condensation polymer obtained by heating a certain type of tertiary aminoalcohol.

U.S.P. 2,589,380. Process for Separating Normal Aliphatic Hydrocarbons from Organic Mixtures Thereof. H. V. Hess, G. B. Arnold, and J. K. Truitt to The Texas Company.

Normal aliphatic and alpha-substituted aliphatic hydrocarbons containing at least 6 C atoms are isolated from organic mixtures by contacting these mixtures with 4,4'-dinitrodiphenyl at a temperature below 160°F. A solid complex of this compound with the said normal aliphatic hydrocarbon or the like is formed, from which this hydrocarbon may be recovered.

U.S.P. 2,589,960. Recovery of Olefin Hydrocarbons. G. C. Ray to Phillips Petroleum Company.

A mixture of olefins and saturated hydrocarbons is contacted with a solution of a cuprous salt in orthophenetidine. The olefin of the mixture is preferentially dissolved by this solution and can, thus, be separated from the undissolved saturated hydrocarbon.

U.S.P. 2,589,979. Solvents for Gasoline Inhibitors. B. R. Strickland to Standard Oil Development Company.

A motor gasoline contains certain small amounts of N-N'-di-secondary-butyl p-phenylendiamine and para-dioxan to inhibit oxidation of gum-formers and the like in the oil.

U.S.P. 2,589,981. Drying of Solid Adsorbents. R. L. Weeks to Standard Oil Development Company.

Petroleum oils boiling in the gas oil and lubricating oil range and containing aromatic type compounds are treated with silica gel to remove these compounds. The enriched silica gel is contacted with a liquid paraffin hydrocarbon solvent of 4-8 C atoms at a temperature slightly below the b.p. of the solvent to remove the adsorbed aromatics. The lean silica gel is finally treated with superheated vapors of the same solvent.

U.S.P. 2,590,322. Adsorption Process. D. H. Imhoff and C. H. O. Berg to Union Oil Company of California.

Gaseous mixtures, such as those obtained in the production of ethylene oxide from ethylene, are separated by contact with a moving bed of lean granular adsorbent and further treatment of the enriched adsorbent by stripping gases.

POLYMERIZATION AND CONVERSION

U.S.P. 2,586,996. Preparation of Poly-

Corrosion —AN ALLY OF THE ENEMY

CORROSION — the great saboteur — works night and day making old storage tanks useless and necessitating costly repairs to new. In some sour crude areas, new tanks have been rendered useless in as little as 18 months.

Now, with steel again in short supply, you will have to get the maximum years of life from each tank so there may be more steel for defense.

NATASCO products will prevent corrosion from getting a start on your new tanks and prevent further corrosion on old ones.

NATASCO corrosion prevention products have been proved by years of successful use. NATASCO also provides experienced crews for the preparation and application of these products.

CONTRACT SERVICES:
Tank Welding Repairs and Maintenance
Installation of Tank Appurtenances
Tank Painting
Application of Protective Coatings
Tank Cleaning — BS&W Emulsion Chemical Treating

Learn how you can get the most in years of additional service from your tankage. Wire, telephone or write for complete information.

The Natasco Company

Lease Tank Service—West Texas Area: Williams Construction Co., Odessa, Texas
California Representative: Coast Contractors, Inc., 2627 Atlantic Ave., Long Beach 6, Calif.
New England Representative: The McKin Company, P. O. Box 711, Portland, Maine

PETROLEUM CHEMICALS DIVISION
NEWS

May ★ One of a Series of Interest to the Petroleum Industry ★ 1952

Du Pont Purchases Plant Site in Texas

A 562-acre tract in the Beaumont, Texas area was recently purchased by the Organic Chemicals Department of the Du Pont Company. The Petroleum Chemicals Division, supplier of tetraethyl lead, is part of this department.

The plant site is bounded by the Neches River and the Kansas City Southern Railroad. Definite plans for plant construction on the new site have not yet been announced. The land, however, was purchased for the purpose of expanding the Company's regular manufacturing activities.

The location is conveniently close to an ample supply of petrochemicals . . . used in making many Du Pont products. There are now three major Du Pont Company plants in Texas, at Sabine, Victoria and Houston.

NEW DU PONT MARKETING AID...

Unique Mileage Calculator Now Available for Your Special Gasoline Promotions

Why does a motorist select *your* gasoline brand . . . or your competitor's?

Miles per gallon is, no doubt, one of his most important considerations—because he can *see* how it affects his pocketbook. That's why many car owners are interested in keeping score on gasoline mileage.

By giving the motorist an interesting gadget that helps him determine his mileage accurately, you can gain his friendship . . . and often create a favorable impression for your brand.

The new Du Pont gasoline mileage calculator is designed to help you do just that. It is essentially a circular slide rule with simple settings that tally miles-per-gallon performance.

The calculator accurately figures the mileage on fuel measured to the nearest fifth of a gallon. And a handy indicator, which the motorist sets with each tank filling, automatically keeps track of his previous mileage. But the tank has to be completely filled at each gas stop to enable the motorist to maintain a continuing check . . . which *is*, of course, to your advantage.

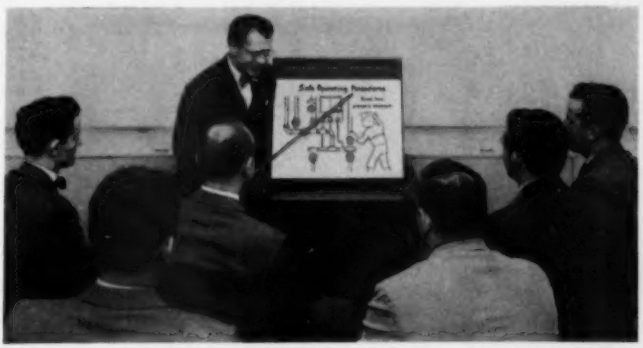
Complete instructions, plus *your* trade-mark and brand name are printed on the front of the calculator. It carries no other advertising. This makes it an ideal tie-in for your special promotions —such as the introduction of a new or improved gasoline, the opening of a new station, or as a low-cost write-in item for testing your advertising or radio program.

The Du Pont calculator design is available to oil companies who, in turn, would have them made with their own brand name and trade-mark in any desired quantity.

New Visual Training Aid On Blending Plant Safety Developed by Du Pont

"Safety" is always a password to the successful handling of tetraethyl lead. And uniform handling procedures are of prime importance in maintaining safety in the blending area.

Since tetraethyl lead was first used in gasoline in the early twenties when Du Pont developed a safe commercial method for making it, a variety of methods for training blending personnel have evolved.



THIS NEW DU PONT TEL SAFETY PRESENTATION can be clearly seen by a group of 20. And it is specially designed for convenient handling by the training instructor or discussion leader.

Now, to fill the need for a single, easy-to-understand tool for training prospective blending plant operators, and as a refresher course for experienced personnel, a carefully detailed turnover presentation has been developed by Du Pont. And this new visual training aid may well become the standard for training blending plant operators throughout the country.

CLEAR, SIMPLE

Stressing "correct operating procedures" as a means to safety, the presentation convinces viewers that correct operation, while not difficult, *is vitally important*. And the presentation is fortified with plenty of "reason why" to make its message penetrating.

For clarity and human interest, the turnover is made up of a series of easy-to-understand illustrations and diagrams. The simple, straightforward text on the back of the turnover is readily visible to the instructor, either for reading verbatim or as a guide for

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT

PETROLEUM CHEMICALS DIVISION
NEWS

DU PONT

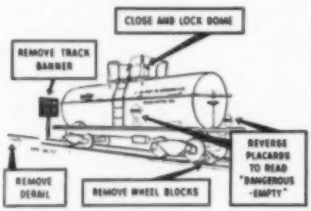
CONTINUED *Safety Turnover*

delivering the presentation with his own personal showmanship.

Big enough for visual impact, yet small enough for convenient handling, the 47 pages are 18½" by 24". Color has been added to many of the illustrations to show graphically and vividly the actual flow of liquids during the unloading and blending operations.

STEP BY STEP

The presentation is divided into two sections—tank car unloading and blending plant operation. Health precautions and the use of proper procedures are analyzed step by step.



A TYPICAL PAGE shows graphically the important steps in preparing a TEL tank car for release.

In addition to the actual turnover, protected by an attractive "Fabrikoid" binder, an "Instruction Manual" has been prepared to assist the speaker in the initial stages of becoming familiar with his presentation. The handy 8½" by 11" size of the manual permits the speaker to study his material at his desk, at home, on a plane or train without the necessity of handling the larger turnover.

NEVER.... touch anything contaminated with TEL compound without rubber gloves
ALWAYS... bathe thoroughly after working with TEL....

HUMOROUS FIGURES add interest to a serious point.

Suitable for either the novice or experienced blending crews, the new Du Pont turnover follows the style of the National Safety Council's "Safetygraph."

Coordinator of Du Pont District Laboratories

THE PROMOTION of ARTHUR F. BOWE to the position of Laboratory Coordinator was recently announced by the Du Pont Petroleum Chemicals Division.

Since 1949, Bowe has been manager of the Division's Eastern District Laboratory at Wilmington. This laboratory serves refineries on the Atlantic seaboard of the United States. He had previously been acting manager of the Gulf Coast District Laboratory at Houston, Texas, and supervisor of the analytical section of the Du Pont Petroleum Laboratory.

Before joining Du Pont in 1947, Bowe was with the Cities Service Oil Company at East Braintree, Mass. He was graduated, with a B.S. in chemistry, from Tufts College in 1939 and during his senior year was a teaching assistant in chemistry.

ARTHUR F. BOWE

Du Pont Historical Highlights

An early supplier of Du Pont was a Philadelphia firm that sold kegs to the powder mills. The containers were all sizes and qualities, causing confusion in sales and frequent losses from breakage and dampening of the powder. Later, Alfred Victor du Pont, son of the founder, built his own cooperage shop, designed a satisfactory standard keg and, thereafter, made the containers on the mill premises.

Today, containers, ranging all the way from paper envelopes to the tank cars carrying Du Pont's TEL, rank among the most important products Du Pont purchases. And Du Pont buys from more than 30,000 firms. Petroleum companies, suppliers of the petrochemicals used in making Du Pont products, rank well up among the firms supplying the largest volume of commodities bought by Du Pont.

MOVIES AND LITERATURE AVAILABLE

Here is a partial listing of the movies, bulletins, reports, booklets and aids available to you through the nearest Du Pont Petroleum Chemicals Division district office:

Safety for the Small Refinery — A 42-page book on how to set up an effective small refinery safety program . . . . . Serial A-2848

Stability of Present-Day Gasolines — A 12-page paper on the value of storage tests — as compared with induction period—for determining stability of modern gasolines Serial A-3199

Pipeline on Wheels—A 26-minute, full-color movie on tank truck safety. Suitable for both training and public relations purposes.

Prints of Du Pont films are available to oil companies for training and public relations purposes. They may be borrowed or purchased.

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. . . through Chemistry

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Petroleum Chemicals Division • Wilmington 98, Delaware

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A-3398

Printed in U. S. A.

Patents

merizable Non-Polar Substances. Fritz Rosenthal to Radio Corporation of America.

A volatile non-polar product, which is instable in the presence of heat is prepared from a reaction mixture heated by radio-frequency energy. Thus styrene and non-polar substituted styrene compounds can be produced as monomers without polymerization.

U.S.P. 2,587,729. Process for Conversion of a Mixture of Hydrocarbonaceous Solids and Liquid Hydrocarbons. L. C. Huff to Universal Oil Products Company.

A mixture of hydrocarbonaceous solid material, such as oil-shale, tar sand, and the like, and a fluid medium is subjected to elevated temperature under non-coking conditions and further treated under conditions to effect pyrolytic conversion of the mixture in a process. Details of which are claimed.

U.S.P. 2,587,791. Resinous Copolymerization Products from Aromatic Fulvenes. R. B. Thompson and H. S. Bloch to Universal Oil Products Company.

Unsaturated hydrocarbons with 1-2 double bonds are copolymerized with aromatic monofulvenes at a temperature of 25-300°C. Resins are produced.

U.S.P. 2,588,075. Method for Gasifying Carbonaceous Fuels. F. T. Barr, B. E. Roetheli and W. G. Scharmann to Standard Oil Development Company.

Solid carbonaceous materials, such as oil-shale, tar sands, coal, and the like, are converted into valuable volatile fuels by a process claimed in detail, wherein efficient generation of heat from the solid materials is obtained with the production of CO_2 in preference to CO as gaseous combustion product.

U.S.P. 2,588,076. Method for Gasifying Fuels. E. J. Gohr to Standard Oil Development Company.

The process of this patent is related to that of U.S.P. 2,588,075. It is concerned with the production of gaseous fuels from solid carbonaceous materials.

U.S.P. 2,588,323. Production of Ethylene. L. Kniel to The Lummus Company.

Details are claimed for the conversion of a normally gaseous hydrocarbon mixture heavier than methane to an unsaturated hydrocarbon of lower mole weight, a rectifying absorber being used for removing all methane and hydrogen, and methyl alcohol being introduced into the system following the deethanizer.

U.S.P. 2,588,331. Recovery of Alkylation Sludge Acids. N. Titlestad to Nicolay Titlestad Corporation.

Acid sludge as resulting from the alkylation process of producing gasoline and containing H_2SO_4, water, and at least 4 percent hydrocarbons is continuously passed through a reactor where it is heated to the constant boiling temperature of 98 percent acid. Concentrated SO_3 gas is continuously passed into the reactor in an amount sufficient to react with all the carbon of the hydrocarbons to form SO_2 and CO_2. More details are claimed.

HOW MUCH ARE SLIPPING ACCIDENTS COSTING YOU?

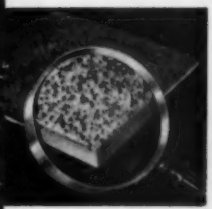
ACCIDENT REPORT
Cause of accident:
Man fell on a slippery floor.
Means of prevention:
Install A.W. ALGRIP Abrasive Rolled Steel Floor Plate.

There's an easy, economical way to end slipping accidents that steal man-hours and drag production down. Put positive non-slip protection in your plant with exclusive A.W. ALGRIP Abrasive Rolled Steel Floor Plate.

NON-SLIP—EVEN ON STEEP INCLINES!

ALGRIP is made by rolling tough abrasive grain (the same kind used in grinding wheels) *uniformly* as an integral part of the steel plate's upper portion. When you walk on ALGRIP, hundreds of tiny safety brakes grip your feet at every step. *Result:* It's virtually impossible to slip—even on steep inclines.

WEAR WON'T WEAR OUT ITS SAFETY!



ALGRIP's safety isn't merely a surface treatment. Note the even distribution *and* depth of the abrasive grain. As the surface wears, new particles are exposed, so ALGRIP keeps its non-slip qualities for a lifetime. It needs no maintenance. Rolled steel makes it stronger than other abrasive floorings. It withstands hard blows and heavy loads without cracking or breaking. And thinner sections can be used without reducing load carrying capacity.

Get Full Details of ALGRIP Today

Our new Booklet A-18 gives complete technical details, suggests uses. Write for your free copy. *It may save you countless hours and dollars!*

A.W. ALGRIP ABRASIVE ROLLED STEEL FLOOR PLATE

ALAN WOOD STEEL COMPANY

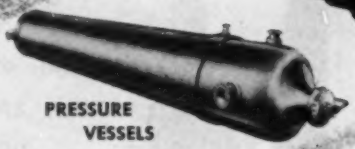
Conshohocken, Pa.

Other products: PERMACLAD Stainless Clad Steel • A. W. SUPER-DIAMOND Floor Plate • Plates • Sheet • Strip • (Alloy and Special Grades)

Over 125 years of iron and steel making experience.

HEADQUARTERS FOR HEAVY STEEL FORGINGS

STEEL ROLLS



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Custom Steel Makers to Industry

PRODUCERS OF FORGINGS, ROLLS, RINGS, CORROSION AND HEAT RESISTING CASTINGS

Patents

U.S.P. 2,588,358. Process of Polymerization of Propylene with Liquid Catalyst Complex. Carl S. Carlson, Robert S. Merrington and Frank A. Biribauer to Standard Oil Development Company.

A catalyst solution consisting of a complex of BF_3 and diisopropylether in a complex of BF_3 and diethyl ether is used to polymerize propylene at 0-91°C. and produce predominantly C_6 through C_{36} polymers.

U.S.P. 2,588,425. Preparation of Tetra-Isobutylene. D. R. Stevens and R. S. Bowman to Gulf Research & Development Company.

Tetra-isobutylene is prepared from diisobutylene by contact with a BF_3-ether complex at 0-55°C. in the presence of an inert reaction solvent.

U.S.P. 2,588,426. Preparation of Tri-Isobutylene. D. R. Stevens and R. S. Bowman to Gulf Research & Development Company.

Isobutylene is introduced below the surface of a liquid body of equimolecular BF_3-ether complex maintained at -15-70°C. Tri-Isobutylene is predominantly formed.

U.S.P. 2,588,890. Allyl Alcohol-Styrene Copolymers. E. C. Shokal and P. A. Devlin to Shell Development Company.

A mixture of allyl alcohol and 10-40 percent styrene is heated at 100-200°C. while bubbling oxygen therethrough. The resulting copolymer is completely esterfied with unsaturated fatty acid of 12-20 C atoms. A drying ester is formed.

U.S.P. 2,588,975. Reaction Rate of an Emulsion Polymerization Process. C. F. Fryling and A. E. Follett to Phillips Petroleum Company.

In the emulsion polymerization of monomeric material comprising styrene, 0.1-10 millimols of diisopropylbenzene hydroperoxide, or the like, and 0.05-2 parts of an alkyl mercaptan with 8-16 C atoms, per 100 parts by weight of total monomeric material, are dissolved in Styrene. The resulting solution is used under special conditions and in the presence of an emulsifier for the emulsion polymerization of monomeric material at a temperature of -40° to 30°C.

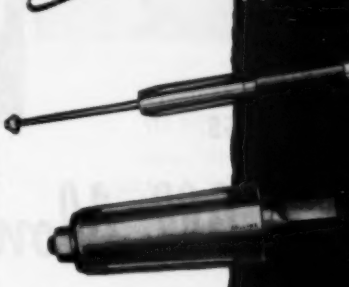
U.S.P. 2,589,109. Fluidized Distillation of Shale. H. Z. Martin and F. T. Barr to Standard Oil Development Company.

In the continuous distillation of oil shale to produce normally liquid hydrocarbons, the shale is maintained in the distillation zone in the form of a dense fluidized bed of subdivided solids. Solid lignite or bituminous coal of particle size different from that of the fresh oil shale is added to this zone, and free-oxygen containing gas is supplied to generate heat by burning these bituminous materials. The generated heat is employed by direct heat exchange between the oil shale and those materials. A vapor stream of normally liquid hydrocarbons is continuously withdrawn.

U.S.P. 2,589,124. Method and Apparatus for Handling Fluidized Solids. John W. Packie to Standard Oil Development Company.

"All those in favor of BETTER TUBE ROLLING methods say AIRETOOL"

Put it to a vote by the operators who have used all kinds of tube rolling equipment, and you will come out with an overwhelming preference for AIRETOOL. This is true because AIRETOOL tube expanders are easy to use . . . don't break down when the going is rough . . . produce neatly rolled joints that withstand highest pressures.



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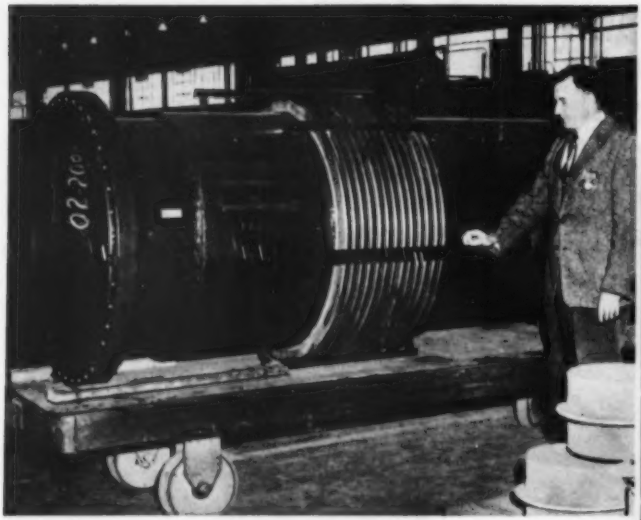

CATALYTIC CRACKER EXPANSION JOINT ASSEMBLY . . . one of the larger sizes of Sola-Flex equipment of this type fabricated from stainless chromium-nickel steel.

WELDING STAINLESS STEEL FABRICATED expansion joint assembly at Solar Aircraft Company's San Diego plant.

EXPANSION JOINTS OF STABILIZED STAINLESS

Save Money All Along the Line

- **RESIST CORROSION AND HEAT**
- **FORM AND WELD READILY**

In oil refineries, chemical plants, steam and gas turbine installations . . .

Wherever pipe carries material at elevated temperatures . . . subjecting components to thermal expansion and contraction . . . that's the field for stabilized stainless steel bellows and expansion joints.

A new line of such equipment has been developed by Solar Aircraft Company of San Diego, California, and is now available under the trade name "Sola-Flex."

Made from chromium-nickel stainless steels of the stabilized types (A.I.S.I. Types 321 and 347) "Sola-Flex" bellows and expansion joints have established completely satisfactory performance records in a variety of rugged applications.

In addition to high strength and corrosion resistance, these types of stainless steel, in gauges from .005" to .125", possess good forming and welding characteristics, and withstand fatigue, impact, wear and abrasion.

Industrial applications demand such properties. For example, expansion components to accommodate 6" to 36" pipe in a large catalytic cracking plant called for the stamping and forming of more than 600 diaphragms. And since the pipe carries a highly abrasive catalyst dust at 1100°F., it requires the hardness, creep-strength and stamina which stabilized chromium-nickel stainless provides.

The bulk of nickel produced at present is being diverted to defense. However, through application to appropriate authorities, chromium-nickel stainless steel is obtainable for many end uses in defense and defense supporting industries. Counsel and data on alloys containing nickel, for your present or future projects, are yours for the asking. We invite your inquiries.

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Patents

Two fluid bed reactors are interconnected by means of a U-shaped conduit and solid is passed from one reactor to the other at a controlled rate and without use of valves; the legs of the U extend substantially below the bottom of the vessels and an effective gas seal is maintained between the vessels by flowing finely divided solid downwardly through one leg while in admixture with an aerating gas in an amount limited to maintain a dense fluidized body of solids. The flow of solids is continued around the base of the U and upward through a substantial portion of the opposite leg without materially changing the density of the fluid. Additional gas is then admixed in the remainder of the conduit to lower the density of the fluid body and control the rate of entrance into the second reactor.

U.S.P. 2,589,862. Method and Apparatus for Contacting Gases and Pulverized Solids. D. H. Putney to Stratford Engineering Corporation.

Hydrocarbon vapors and gases are contacted with pulverized solids, such as catalysts, by passing the mixture of gases and solids upwardly in a centrally located stream in a contacting zone. The entrained solids are cascaded outwardly and reversing their flow while the gases are separated therefrom. The solids are caused thence to pass in an annular stream surrounding the upflowing stream and are passed from the bottom of the annular stream to the bottom of the central stream and from the annular stream to the central stream at intervals between the top and bottom of these streams. A level of solids is maintained immediately above the top of these streams.

U.S.P. 2,589,919. Method of Producing a Butadiene-Acrylonitrile Copolymer Latex of High Solids Content. E. Arundale and F. Bascom to Standard Oil Development Company.

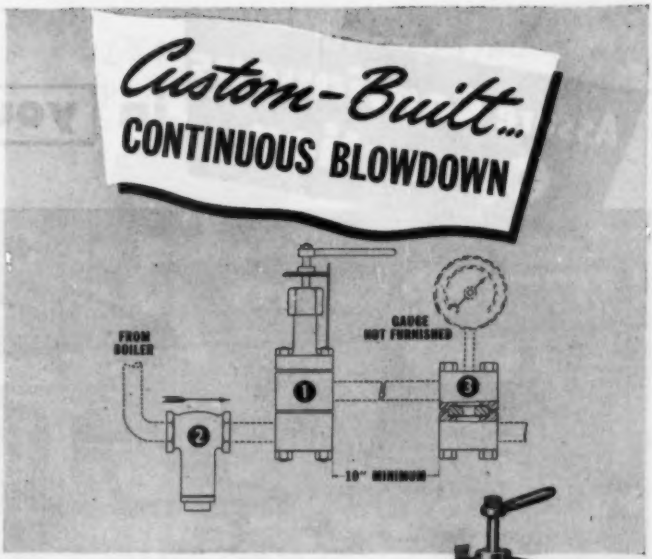
Details are claimed of a process for the emulsion polymerization of certain proportions of conjugated diolefins and acrylonitrile in the presence of an alkali persulfate catalyst, a certain type of electrolyte and a disperser, e.g., an alkali salt of formaldehyde. Latex of high solids content is directly obtained.

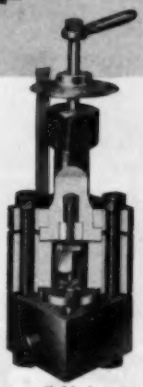
U.S.P. 2,589,969. Production of Fulvene Hydrocarbons. H. G. Schutze and E. F. Wadley to Standard Oil Development Company.

A mixture of a hydrocarbon containing at least one methylene group allyl to two double bonds and having 5-9 C atoms, such as cyclopentadiene, or decomposable polymers thereof, and a carbonyl compound having 2-5 C atoms, such as acetone, is contacted in the vapor phase at a temperature of 400-900°F. with an oxide of Al, Mg, or Si or a mixture thereof. Fulvene hydrocarbons are formed.

U.S.P. 2,590,539. Method of Catalyst Control in Organic Reactions. T. B. Hudson to Phillips Petroleum Company.

In exothermic organic conversions in the presence of a catalyst, e.g. in the polymerization of low-boiling olefins in the presence of a synthetic silica-alu-





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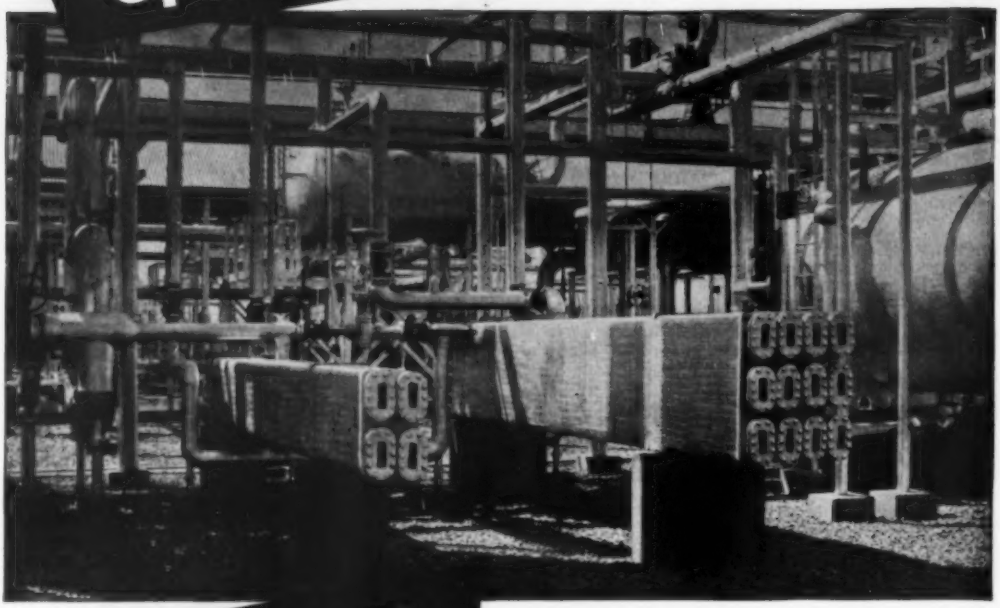

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● By simply manifolding an extra parallel stream into a bank of Brown Sectional Exchangers, one stream after another can be taken off-line, and cleaned, while the exchanger *operates at full capacity.*

This avoids the necessity of carrying a 100% standby unit to insure continuous operation. It permits the sections to be cleaned as frequently as the duty requires, *without affecting other parts of the plant,* and assures clean surfaces and efficient operation, year after year, without shut-down.

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mina catalyst, where the fluid reaction mixture is passed through a reaction zone and the temperature in this zone increases in the direction of flow due to the exothermic heat of reaction, solid mobile catalyst is introduced at a plurality of points spaced in the direction of flow and is passed through this zone countercurrently to the reaction mixture. The quantity and activity of the catalyst is separately controlled at each introducing point to provide a decreasing amount of catalyst activity in the direction of the reactant flow.

CRACKING AND REFORMING

U.S.P. 2,587,149. Hydroforming with Sulfate Regenerated Catalyst. Marion H. Gwynn.

Metal catalysts used in the hydroforming of sulfur rich stocks, such as nickel powder, are regenerated by oxidizing the nickel sulfide to sulfate and treating the latter with an aqueous solution of a highly alkaline compound of sodium, e.g. sodium carbonate. The nickel is precipitated as a readily reducible oxygenated compound which can be returned to the hydroforming process.

U.S.P. 2,587,425. Reforming Naphtha with Activated Carbon Catalyst. Clark E. Adams and Charles N. Kimberlin, Jr. to Standard Oil Development Company.

Virgin naphtha is reformed at 900-1100° F. and a pressure of about 75 psig. over an activated carbon catalyst. A naphtha feed rate of about 1.5 wt./wt./hr. is used and a diluent consisting of recycled reaction gases may be employed. The catalyst is periodically regenerated by countercurrent steam treating at 1000-2000° F.

U.S.P. 2,587,669 - 2,587,670. Processing Liquid Hydrocarbons. W. W. Weinrich to Houdry Process Corporation.

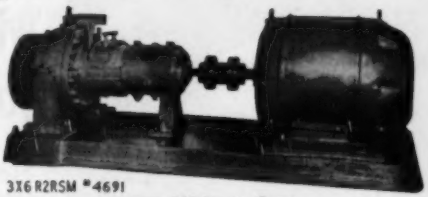
A hot granular adsorptive contact mass is engaged with a vapor stream compatible with hydrocarbons, to effect elevation of the contact mass into and through a vertical channel. Liquid hydrocarbons are admitted into the channel to effect at least partial vaporization of the hydrocarbons by heat exchange with the contacting granular mass. The liquid hydrocarbons are introduced into the channel at a locus where the contact mass is in positive upward motion and is present in sufficiently high concentration to adsorb the liquid hydrocarbons, and the sensible heat content is sufficient to effect said vaporization and at least partial cracking. According to U.S.P. 2,587,670, the liquid hydrocarbon oil is introduced peripherally into the vertical channel from opposing directions. The vaporized oil separated from the discharged contact material is further contacted with a compact downwardly moving bed of this contact material under working conditions.

U.P.S. 2,587,703. Cracking Heavy Oils in Presence of Oxygen. R. M. Deanesley to Universal Oil Products Company.

A process is claimed for the autothermic cracking of heavy hydrocarbon oil

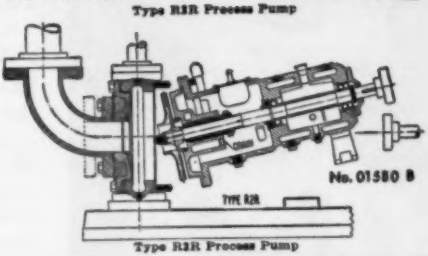
DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



3X6 R2RSM #4691

Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R. Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute. Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

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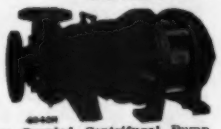
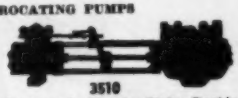


Close Coupled Centrifugal Pump



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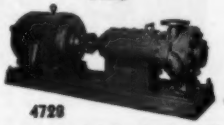
Pedestal Mounted Centrifugal Pump

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



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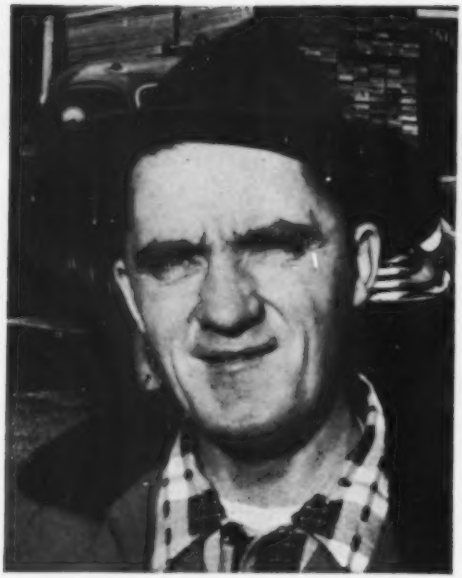

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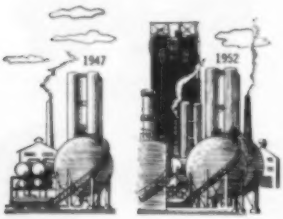
Standard's income *sometimes raises such comments as: "You people do a lot of business. You must be rolling in dough. What do you do with all the money you make?"*

The answer is a matter of public record. But in brief—after we've paid for materials, wages, employee benefits, and miscellaneous expenses . . . wear and tear on plants and equipment . . . interest on our long-term debts . . . and, in the last 5 years, more than $405,000,000 in taxes—then what's left, the "money we make," goes this way:

We invest in research and technical service—more than $35,000,000 in the last 5 years—to develop better ways of finding oil, increasing the yield, cutting costs, creating new business. That brings you new and improved products, with prices held down as we compete for your patronage.

Exploration here and abroad has cost us more than $229,000,000 in the last 5 years. Known crude reserves are at an all-time high. But these deposits were the easiest to discover. Though the earth holds vast hidden reserves, it now costs millions to find each new field, to assure continuing supplies.

And finally, after setting aside funds for future operation, our more than 100,000 shareholders get what money remains—last year $2.60 a share, their return on savings invested in Standard. So almost all the "money we make" goes right back into circulation.



We put funds into facilities—in the last 5 years, more than $644,000,000. The need for oil products keeps growing. Standard must replace old wells, increase crude production; add to the capacity of refineries, pipelines, tankers, and all other things we need to serve you well.

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to produce lower boiling and lower mole weight hydrocarbons, such as olefins, dienes, and aromatics, while trapping and eliminating the tar fog from the product stream. This is achieved by passing the products of oxidation and cracking in a continuous stream upwardly through a fluidized bed of coke-like particles.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,586,929. Separation of Oxygenated Organic Compounds. H. W. Fleming to Phillips Petroleum Company.

The normally liquid products of a Fischer-Tropsch synthesis are separated into a hydrocarbon phase and an aqueous phase. The aqueous phase is freed from products boiling up to 77°C. An azeotrope consisting of methyl-n-propyl ketone, ethyl alcohol and water is obtained by distillation from the remaining reaction products. Ethyl alcohol in the azeotrope is reacted with no more than the stoichiometric equivalent of formic acid or acetic acid. A different, lower-boiling fraction containing ester thus formed, and a higher-boiling fraction enriched in methyl-n-propyl ketone are recovered by distillation from the reaction mixture obtained.

U.S.P. 2,588,452. Hydrocarbon Synthesis Using a Spent Ammonia Synthesis Catalyst. E. T. Laying to Hydrocarbon Research, Inc.

An iron catalyst containing 0.3-5 percent alkali which has become spent for the ammonia synthesis is used in the reduction of CO without intervening reducing treatment. Temperatures of 425-700°F. and superatmospheric pressure are used for the hydrocarbon synthesis employing a fluidized mass of the catalyst.

U.S.P. 2,588,511. Catalyst for the Synthesis of Hydrocarbons by Reduction of Carbonmonoxide with Hydrogen and Process of Utilizing Same. A. H. Friedman and J. N. Moran to Phillips Petroleum Company.

Hydrogen and CO are reacted at 175-325°C. in the presence of a catalyst consisting of a reduced, ground, fused mixture of iron oxide, a mixed silicate of aluminum and an alkali or alkaline earth metal.

U.S.P. 2,589,273. Process for Desoxygenating and Isomerizing a Fischer-Tropsch Stock. C. W. Montgomery and W. I. Gilbert to Gulf Research & Dev. Company.

A synthetic motor fuel obtained by a Fischer-Tropsch synthesis and containing olefins and oxygenated compounds is passed at a temperature of 300-600°C. over a catalyst comprising alumina and anhydrous HCL. Desoxidation and simultaneous isomerization are effected.

U.S.P. 2,589,523. Blending of Hydroformer Feed Stocks. B. B. Woertz, M. Henderson and C. M. Ridgway to The Pure Oil Company.

A mixture of predominantly paraffinic

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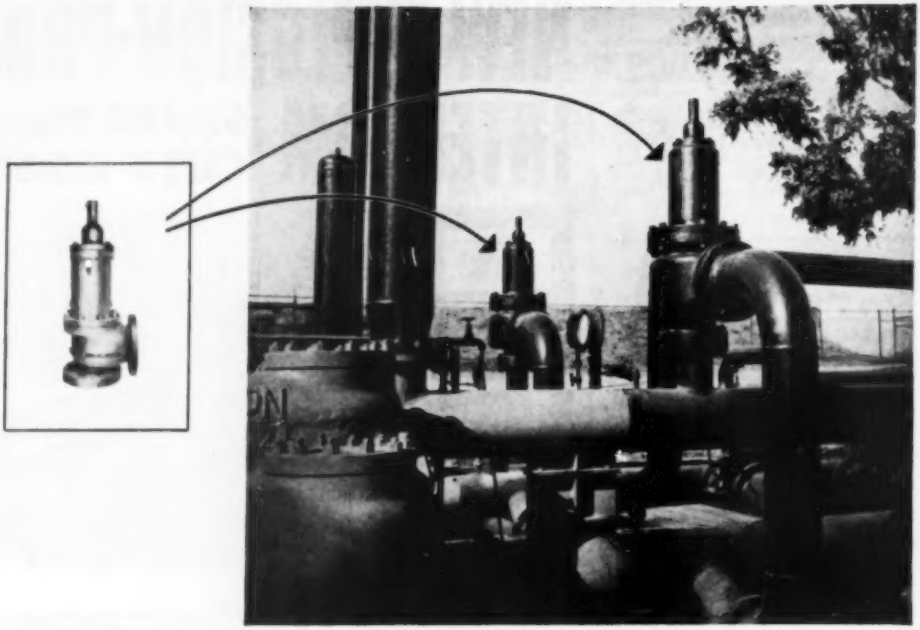

Consolidated Safety Relief Valves installed in pumping equipment at Cities Service Refining Co., Lake Charles, Louisiana.

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Consolidated Safety Relief Valves have outside bevel seat and floating guide construction. The disc moves on a radial seating surface—no leakage under discharge piping stresses. Perfect protection—complete tightness – is assured in the severest service.

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and naphthenic hydrocarbons consisting substantially of two fractions of virgin naphtha boiling within the ranges of 190-300° and 400-500°F. is contacted with a dehydrogenation catalyst, e.g. a combination of a highly porous form of alumina and molybdena, in the presence of hydrogen at temperatures of 850-1100°F. under increased pressure. Alkylated benzenes are recovered.

U.S.P. 2,589,925. Hydrocarbon Synthesis. V. L. Cain and C. E. Hemminger to Standard Oil Development Company.

In order to repress carbon formation on and in a fluidized bed of powdered iron catalyst in a Fischer-Tropsch synthesis and thereby hinder or repress the tendency of the catalyst powder to undergo physical disintegration, the catalyst is preconditioned by treatment with a CO-rich gas under special conditions, and a high hydrogen partial pressure is maintained in the reaction zone.

U.S.P. 2,589,984. Catalyst Stripping of Fouled Catalysts Employed in Hydrocarbon Conversion Processes. W. H. Borcherding to The M. W. Kellogg Company.

In a catalytic conversion process with stripping and regeneration of fluidized catalyst, one stream of hot regenerated catalyst is re-introduced to the conversion zone, while another stream thereof is introduced to the stripping zone. Catalyst from this last-named stream is mixed with catalyst from the conversion zone in the upper part of the stripping zone and is stripped therein. The thus stripped catalyst mixture is returned to the regeneration zone.

DESULFURIZATION

U.S.P. 2,587,987. Selective Hydrodesulfurization Process. L. U. Franklin to Gulf Oil Corporation.

A sulfur-containing hydrocarbon charge stock is fractionated into a plurality of fractions. A high boiling fraction is contacted with a hydrogenation catalyst in the presence of hydrogen and combined with a lower boiling fraction. The mixture is heated to an incrementally higher temperature and contacted with a hydrogenation catalyst. Selective hydrodesulfurization of the charge stock is effected.

U.S.P. 2,589,187. Desulfurizing Agent and its Preparation. E. B. Backens to Socony-Vacuum Oil Company, Inc.

Sulfur and sulfhydryls are extracted from hydrocarbons by an aqueous alkaline solution to which has been added a fraction of thiophene tar soluble in aqueous solutions containing 5-40 percent by weight of alkali metal hydroxide. The thiophene tar is prepared in a special manner.

U.S.P. 2,589,450. Removing Color Bodies Imparted to Hydrocarbons in Sweetening the Same. J. P. Stanton to The Pure Oil Company.

A mercaptan-containing petroleum product is contacted in the presence of free oxygen with a solution of an alkali metal hydroxide and a phenolic type oxidation catalyst, such as wood tar.

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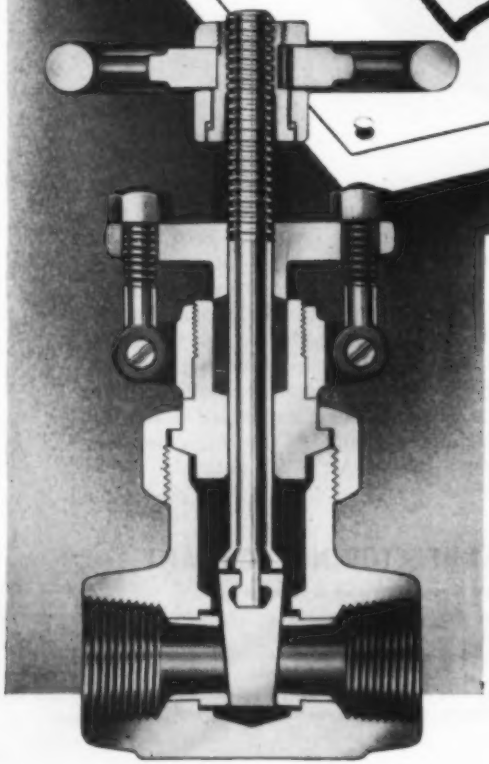

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Patents

This catalyst promotes conversion of the mercaptans to disulfides and effects discoloration of the doctor sweet petroleum product. The discoloration is removed by contacting the treated hydrocarbons with an aliphatic alkanolamine containing alkanol groups of 2-6C atoms, such as mono-,di-, or triethanolamine.

U.S.P. 2,589,663. Removal of Mercaptans from Hydrocarbons. D. C. Bond to The Pure Oil Company.

Details are claimed of a process for the removal of heavy mercaptans from hydrocarbon oils by partial oxidation in an alkali metal hydroxide solution and in the presence of mercaptides.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,586,852. Kaolin-Phosphoric Acid Polymerization Catalyst. Jacque C. Morrell.

A catalyst is described for polymerizing olefin hydrocarbons which consists of a mixture of phosphoric acids and at least 25 percent kaolin, baked at an elevated temperature prior to the polymerization process.

U.S.P. 2,587,328. Purification of Alumina-Containing Materials. A. F. Johnson to Reynolds Metals Company.

Details are described of an improvement in a process for freeing alumina from iron, silica and titania impurities by means of a fusion with cryolite and in the presence of carbon to reduce iron oxide.

U.S.P. 2,587,554. Apparatus for Stripping Finely Divided Solids. John Weikart to Standard Oil Development Company.

Spent or contaminated catalyst particles are withdrawn in a dense, fluidized condition from a reaction zone and are passed through one or more stripping stages while maintaining a fluidized column of particles which column acts as a standpipe to develop hydrostatic pressure due to the circulation of the catalyst particles through the system.

U.S.P. 2,587,599. Catalytic Metal-Alkaline Earth Carbonate Pellet and Its Production. B. B. Corson and G. A. Webb to Koppers Company, Inc.

A catalyst, particularly suitable for hydrogenation reactions, is manufactured by incorporating a catalytic material and a hydrated alkaline earth metal oxide in a catalyst mass, forming this mass and then heating it above the dehydration temperature of the hydroxide in a carbonating atmosphere to simultaneously dehydrate and carbonate the alkaline earth compound. Hard catalyst pellets are obtained.

U.S.P. 2,588,359. Nickel-Copper-Chromia-Alkali Metal Sulfate Catalyst and Its Preparation. H. C. Chitwood, J. F. Fitzpatrick, G. W. Fowler and B. T. Frevre to Union Carbide and Carbon Corporation

A stabilized dehydrogenation catalyst for the conversion of cyclohexanol to phenol is described. It consists of 100 parts nickel; 15-40 parts copper and 0.5-4 parts chromium (mostly in the

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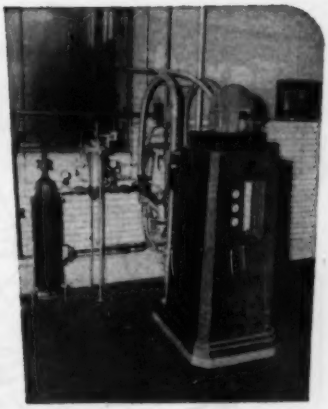

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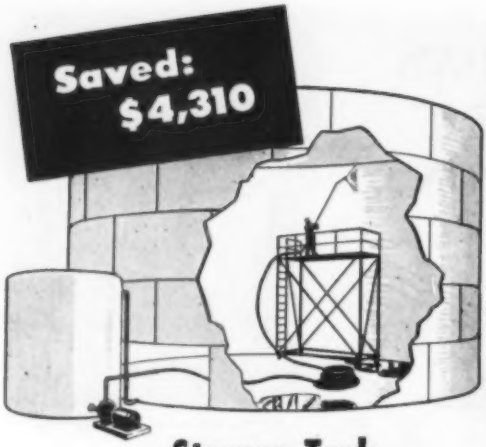

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Patents

form of its oxide); an alkali metal sulfate such as 0.8 parts sodium sulfate, 1 part K_2SO_4, 1.5 parts Rb_2SO_4 or 2 parts Cs_2SO_4.

U.S.P. 2,588,389. Process of Preparing Silicic Acid Sols. R. K. Iler to E. I. duPont de Nemours and Company.

Alkali metal silicate solution is added to a mineral acid solution of pH 0.5-4. The mineral acid contains an insoluble cation-exchanger in its hydrogen form. Addition is effected at such a rate that the pH does not exceed a value of 4. Enough cation exchanger is used to absorb essentially all the cation in the quantity of silicate treated.

U.S.P. 2,588,402. Process and Apparatus for Producing Hydrogel Beads. Thomas H. Milliken to Houdry Process Corporation.

A stream of fast setting hydrosol is discharged from a nozzle rapidly moving, preferably in a circular path, directly above a body of liquid immiscible with the hydrosol, the nozzle being positively actuated to travel at a rate equal to or slightly less than the stream of hydrosol leaving it and in a reaction opposite thereto, resulting in the emerging stream having at most a very low horizontal velocity relative to the body of immiscible liquid. The hydrosol is laid down on the surface of the immiscible liquid which is of lower specific gravity than the hydrosol, and the hydrosol, as a result of interfacial tension, is formed into globules which set as spheroidal beads in the body of immiscible liquid.

U.S.P. 2,589,189. Silica-Alumina-Group VIII Metal Catalyst. Frank G. Ciapetta and William H. Buck to the Atlantic Refining Company.

A catalyst for the treatment of olefins at elevated temperatures consists essentially of a synthetic gel comprising 80-95 percent silica and 5-20 percent alumina, impregnated with 0.1-10 percent by weight of a metal of group VIII of the periodic system.

ISOMERIZATION

U.S.P. 2,589,621. Mesitylene Manufacture. A. P. Lien and D. A. McCauley to Standard Oil Company of Indiana.

Trimethylbenzene isomeric with mesitylene is isomerized in the liquid phase in the presence of certain amounts of liquid HF and BF_3 to form mesitylene. The isomerization is effected at a temperature of 150-400°F.

ALKYLATION

U.S.P. 2,589,057. Alkylation-Dealkylation Process. B. B. Corson and W. M. Kutz to Koppers Company, Inc.

The transfer of an alkyl group from one aromatic nucleus to another is described in which the donor is a polysubstituted aromatic compound, such as diethylbenzene, and the acceptor is an alkylatable aromatic compound such as benzene, both of which will give the same product after group transfer. At least 2.5 moles of acceptor are used per mole of donor. A reaction temperature of below 450°C. is used at 15-60 atmos-

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Patents

phere pressure. Silica-alumina is a suitable catalyst.

U.S.P. 2,589,253. Alkylation of Aromatic Compounds. G. L. Hervert and H. S. Bloch to Universal Oil Products Company.

An alkylatable alkyl benzene is mixed with a normally liquid mono-olefin containing at least 8 C atoms in a mole ratio of alkyl benzene to olefin of at least 4:1. The mixture is treated with a calcined composite of a free phosphorus acid and a siliceous adsorbent at a temperature of 150-375°C., a liquid hourly space velocity of 0.1-10, and pressure sufficient to maintain the alkyl benzene and olefin in liquid state. The alkyl benzene is alkylated.

HEAVY OILS AND WAXES

U.S.P. 2,586,947. Propane-Clay Treating. L. A. Hays, Jr., and R. B. Selund to Standard Oil Company of Indiana.

A hydrocarbon lubricating oil is treated with an adsorbent, such as clay, slurried in a fraction of the charging stock freed from propane. The slurry cooled to a temperature below 200°F. is mixed with a large volume of a propane solution of charging stock to be treated. The resulting mixture is heated to 200-400°F., to obtain decolorization of the charging stock, whereupon the propane is separated therefrom.

U.S.P. 2,587,545. Rust-Preventing Lubricant. L. W. Sproule and L. F. King to Standard Oil Development Company.

A mineral lubricating oil contains 0.2-3.0 percent of a sorbitan monoester of an aliphatic monobasic carboxylic acid with 16-18 C atoms, such as sorbitan monooleate, and 0.2-3.0 percent of a glycol halfester formed by molecular esterification of a C_6- C_8 glycol and a fatty acid material predominantly containing 10-16 C atoms per molecule. The additives prevent rust formation and salt water and acid corrosion.

U.S.P. 2,587,546. Rust Inhibiting Composition. A. H. Matuszak to Standard Oil Development Company.

A mineral lubricating oil contains 0.5-1 percent of a mono-, di-, or trimethylol amino methane salt of oleic acid. The additive has rust preventing properties.

U.S.P. 2,587,581. Azide Modified Fuels and Lubricants. S. Shappirio.

A liquid petroleum distillate contains 0.5-5 percent by weight of an azide having the formula $R.NH.NH.(Q_x\ T_y)\ R^1$, where R and R^1 are alkyl or aryl radicals and $Q_x\ T_y$ is $-SO_2-$, -SO-, -SOS-, -SS-, or -SSS-. The modified petroleum distillate may be obtained by treating a petroleum distillate to produce a diazo salt therein which is then converted in situ to an azide. The additive works as a beneficiating agent.

U.S.P. 2,587,642. Lubricants and Additives for Lubricating Oils and Greases. J. M. Musselman and H. P. Lankelma to the Standard Oil Company of Ohio.

Mineral lubricating oils and greases contain a minor amount of the reaction product of a fatty acid having 12-18 C atoms and an iodine value of not over 70 with 20-35 percent of P_2S_5 or P_4S_3 at

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300°F. for one hour. This reaction product contains a S-to-P ratio higher than that of thiophosphate. Deterioration of lubricants and greases in use is inhibited by this additive.

U.S.P. 2,587,955. Corrosion Preventive Composition. E. R. Barnum to Shell Development Company.

A liquid hydrocarbon contains a minor amount of an oxazoline salt of ricinoleic acid for inhibiting corrosion.

U.S.P. 2,588,273. Lubricating Compositions. A. J. Morway and P. V. Smith, Jr, to Standard Oil Development Company.

A lubricating oil contains at least 25 percent by weight of a sulfur-containing ester of a dibasic acid having the formula R-Z-C-Y-C-Z-R (O O) wherein Y is a divalent aliphatic hydrocarbon radical with 2-8 C atoms or such a radical having a thioether linkage therein, R is an aliphatic hydrocarbon radical with 8-20 C atoms, the sum of R + R being from 14-40, Z is O or S. The composition is thickened to grease consistency with the Li-soap of a saturated fatty acid. It has extreme high pressure qualities.

U.S.P. 2,588,280. Lubricating Grease. R. O'Halloran and J. J. Kolfenbach to Standard Oil Development Company.

A lubricating oil is thickened to grease consistency with 10-20 percent of a mixture of the Na and Ba salts of a mixture of saturated aliphatic acids containing 10-90 percent by weight of an acid in the C_{16}-C_{22} range and 10-30 percent of an acid with 4 C atoms less than the other acid. The grease is satisfactory for the lubrication of metal surfaces over a wide range of temperature conditions and has superior structural stability toward mechanical working.

U.S.P. 2,588,326. Manufacture of Block Grease. A. B. Ogden, R. A. Butcosk, and R. C. Williams to Socony-Vacuum Oil Company, Inc.

In the cooking of a mineral lubricating oil fraction with fatty soaps or fatty acids together with saponifying compounds for the manufacture of a block grease, less than 1 percent by weight of an ester of a dibasic carboxylic acid with an aliphatic alcohol, e.g. di-isobutyl adipate, is added to the cooking batch. The so-called "bread loafing" of the block greases in the cooling pan is inhibited by this additive.

U.S.P. 2,588,412. Mineral Oil Compositions. A. C. Rocchini to Gulf Research and Development Company.

A mixture of about equimolecular quantities of mixed alkenyl substituted succinic acid anhydrides and an amine of the group consisting of trimethyl-, triamyl-, triethanol-, tribenzylamine, pyridine, etc. is kept at about 250°F. for five minutes. A minor quantity of the reaction product incorporates corrosion inhibiting properties to a major amount of mineral oil.

U.S.P. 2,588,556. Manufacture of Grease Compositions. R. J. Moore and W. Saarni to Shell Development Company.

Grease is made from alkali metal and alkali earth metal soaps by heating a slurry of the soap and lubricating oil to 180-250 C. until a homogeneous non crystalline mixture has formed, cooling the grease to its gelation phase and heat treating it between 100-172°C.

U.S.P. 2,588,639. Production of Drying Oils by HF-Hydrocarbon Processing. R. J. Lee and Paul D. May to Pan American Refining Corporation.

A polyolefin containing 4 to 6 double bonds per mole is complexed with HF. The complex is treated with an aqueous HF solution containing 50-80 percent HF while removing heat of hydrolysis. The hydrolysis is accomplished at gradually increasing temperatures between 85-200°F. The hydrocarbon is freed from HF and fractionated.

U.S.P. 2,589,317. Nonfoaming Oil Composition Containing Polymeric Silicone. D. W. Young and S. G. Gallo to Standard Oil Development Company.

A hydrocarbon oil of the gas oil to lubricating oil viscosity range contains a small amount of an oil-soluble solid gel repolymerization product of a liquid hydrocarbon-silicone polymer. The additive serves as a defoaming agent.

U.S.P. 2,589,326. Organic Phosphorus Ester-P,S, Reaction Products and Oil Compositions Containing the Same. E. A. Oberright to Socony-Vacuum Oil Company, Inc.

A mineral lubricating oil contains a small amount of a P- and S-containing product obtained by reacting at a temperature of 100-200°C. 1/8-1 mole of

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Patents

P_2S_5 with 1 mole of an alkemyl phosphite ester of the formula:

$$\begin{matrix} RO\diagdown \\ RO—P \\ RO\diagup \end{matrix}$$

wherein R is alkyl, alkaryl or alkenyl and at least one R is an alkenyl radical. The additive stabilizes the oil against oxidation.

U.S.P. 2,589,973. Lubricating Grease Composition. P. V. Smith, Jr. and A. J. Morway to Standard Oil Development Company.

A lubricating oil is thickened to a grease consistency by a metal soap of aliphatic carboxylic acid comprising at least ⅓ of an acid of the formula.

$$\begin{matrix} R_1OH \\ | \\ O \\ \| \\ R_3—CH—R_2—COOH \end{matrix}$$

wherein R_1 and R_2 are alkyl groups of 3-12 C atoms each, and R_3 is an alkyl group of 2-6 C atoms.

U.S.P. 2,590,451. Metalworking Lubricant. G. L. Perry to Shell Development Company.

A metal fabricating lubricant consists of a blend of a microcrystalline slop wax, 20-40 percent by weight of gas oil and an amount of 1-5 percent of polyalkylene glycol diester.

U.S.P. 2,590,490. Process for Refining Lubricating Oil. B. C. Benedict to Phillips Petroleum Company.

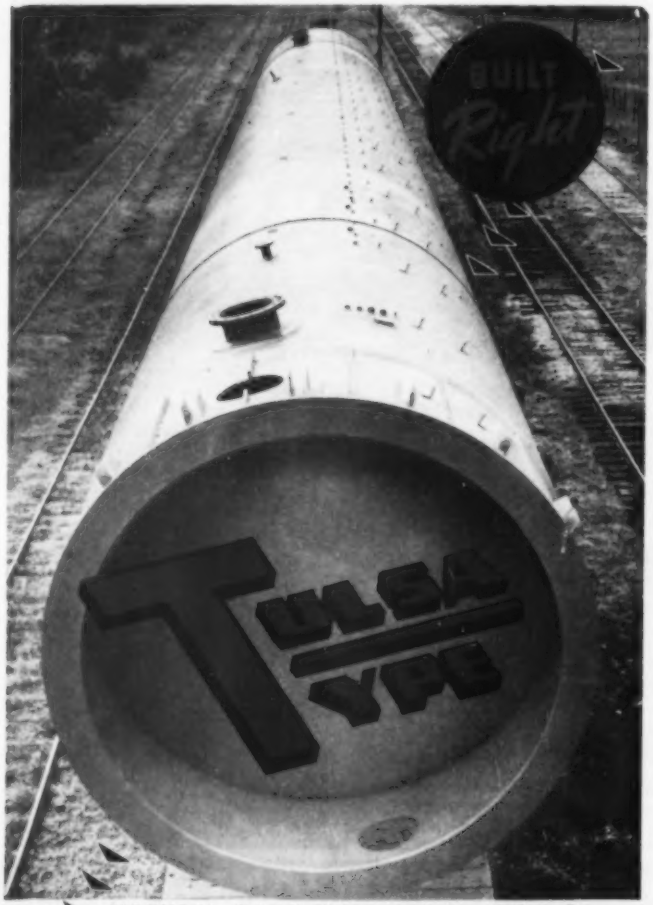
Details are claimed for refining lubricating oil by means of a normal paraffin hydrocarbon solvent having not more than 4 C atoms, such as propane, and a HF-rich phase.

U.S.P. 2,590,786. Grease. J. W. Nelson to Sinclair Refining Company.

A lubricating oil is thickened to a grease by a mixture of high mole weight microcrystalline wax acids produced by complete oxidation of such a wax containing 34-55 C atoms.

U.S.P. 2,590,801. Grease Composition. J. W. Teter and J. W. Nelson to Sinclair Refining Company.

The object of this patent is closely related to that of U.S.P. 2,590,786. The soaps of the wax acids named there are here employed as the thickening means.



NATURAL GASOLINE PLANTS - Oil Refinery Equipment - Steel Plate Fabrication - Structural Steel Warehouse Steel

FLINT STEEL CORPORATION

TULSA, OKLAHOMA

PETROCHEMICALS

U.S.P. 2,587,107. Process for Producing Carbon Black. George N. Cade to Phillips Petroleum Company.

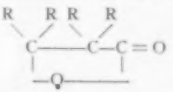
In a process for producing carbon black containing tar, the tar is extracted by means of a chlorinated hydrocarbon solvent of specific constitution.

U.S.P. 2,587,468. Ethylene Oxide Process. R. L. Heider to Monsanto Chemical Company.

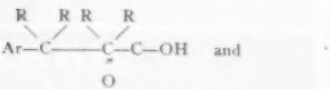
In the production of ethylene oxide by the catalytic oxidation of ethylene with oxygen-containing gases in contact with silver surfaces, 10 to 100,000 parts per million on a volume basis of organic phosphates, such as triethyl, tricresyl, or triphenyl phosphate, are fed to the reactant stream. The extent of oxidation and a selection of the reactions may be controlled by the additive.

U.S.P. 2,587,540. Method for the Preparation of Alpha-Beta Unsaturated Ketones and Aralkyl Carboxylic Acids. F. W. Shaver to The B. F. Goodrich Company.

An aryl hydrocarbon is mixed with a Friedel-Crafts catalyst. A saturated aliphatic beta-lactone of the structure.



wherein R is hydrogen or a lower alkyl radical is added to the mixture cooled below 10°C. in an amount such that there are present 1-5 moles of catalyst for each mole of the beta-lactone. The resulting mixture is heated to reflux temperature. A water layer formed is separated from a water-insoluble layer. The latter is subjected to distillation to recover therefrom compounds of the structures



U.S.P. 2,587,858. Production of Oxygenated Compounds. A. I. M. Keulemans to Shell Development Company.

Carbonylation of olefins with CO and H_2 is affected by continuously supplying cobalt catalyst to the carbonylation reactor in the form of cobalt hydrocarbonyl which may be formed in a previous, non-

STRATOSPHERE PRESSURES DUPLICATED

U. S. Government Research maintains a wind tunnel at the University of California for testing parts of airplanes and rockets. In this tunnel, altitudes up to 75 miles in the stratosphere are duplicated by a five stage Evactor, a steam jet vacuum-producing unit designed and built by Croll-Reynolds to work in the range of a few microns of mercury absolute.

Croll-Reynolds five stage Evactors are built in various sizes, the smallest of which handles many times the volume of the largest mechanical vacuum pump. The same careful work and precision which produced these five stage units goes into every C-R Evactor from the one stager yielding a pressure of four or five inches of mercury absolute to the four stage unit designed for work in the range of 0.15 to 3.0 mm. of mercury absolute.

Many thousands of Croll-Reynolds Evactors are in regular operation, some of them for over 30 years. They are installed in every state of the U. S. and in many foreign countries. Let our technical staff help you with your vacuum problems, including flash cooling of water and aqueous solutions.

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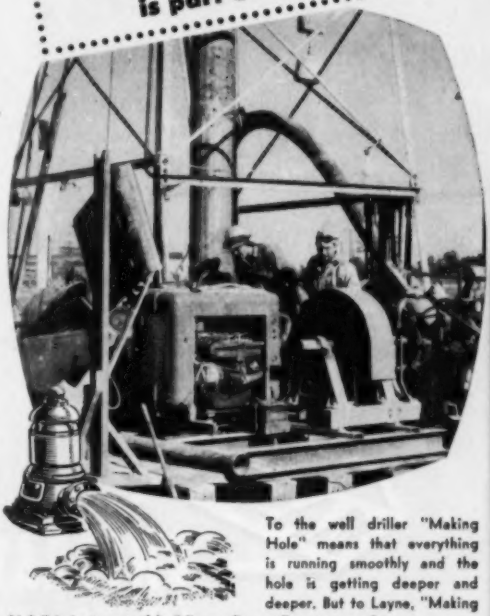
"Making Hole" is part of our job!



To the well driller "Making Hole" means that everything is running smoothly and the hole is getting deeper and deeper. But to Layne, "Making Hole" is just part of building a fine well water supply.

Before a single rig is placed, Layne has used a lot of know-how planning, plotting and figuring out such things as; what size casing and what depth it is to be set, what kind and how much sand screen to use, what kind and size shafting to use and how much horse power the motors should have to produce the stipulated amount of water against a certain indicated pressure. Once all of these answers are on paper, they must be transmitted into an underground construction project—a task that requires more than ordinary skill and ability.

But whether for a single unit or many, you may be sure that if installed by Layne, all will have the same peak efficiency, operate with precision smoothness and be of utmost dependability for now and the years to come.

For late catalogs or specific information on any phase of Layne's water development services, address

LAYNE & BOWLER, INC.
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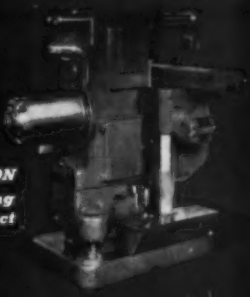
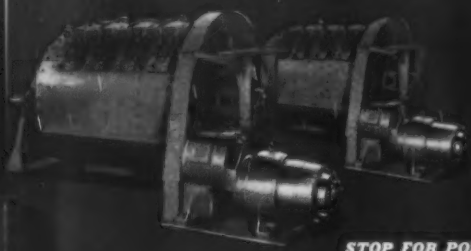
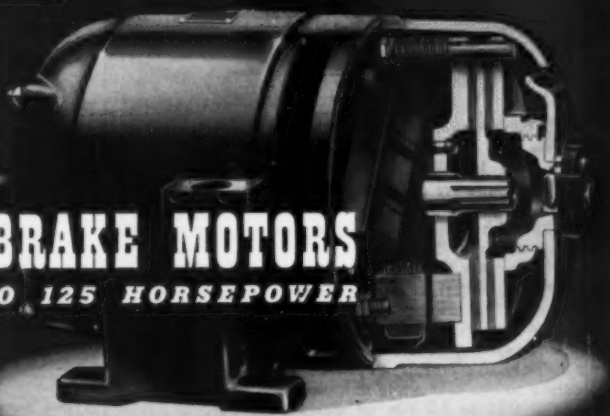
WATER WELLS
VERTICAL TURBINE PUMPS
WATER TREATMENT



SPEED UP PRODUCTION
Save time by stopping quickly with a compact integral brake unit



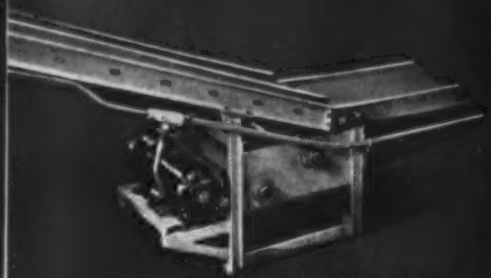
STOP FOR POSITION
Stop at the desired point for quickly and conveniently loading and unloading



MASTER UNIBRAKE MOTORS

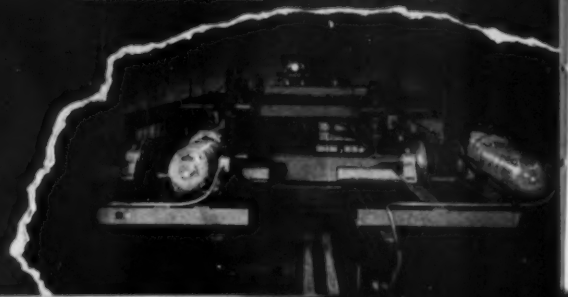
1/8 TO 125 HORSEPOWER

THE MASTER ELECTRIC COMPANY • DAYTON, OHIO

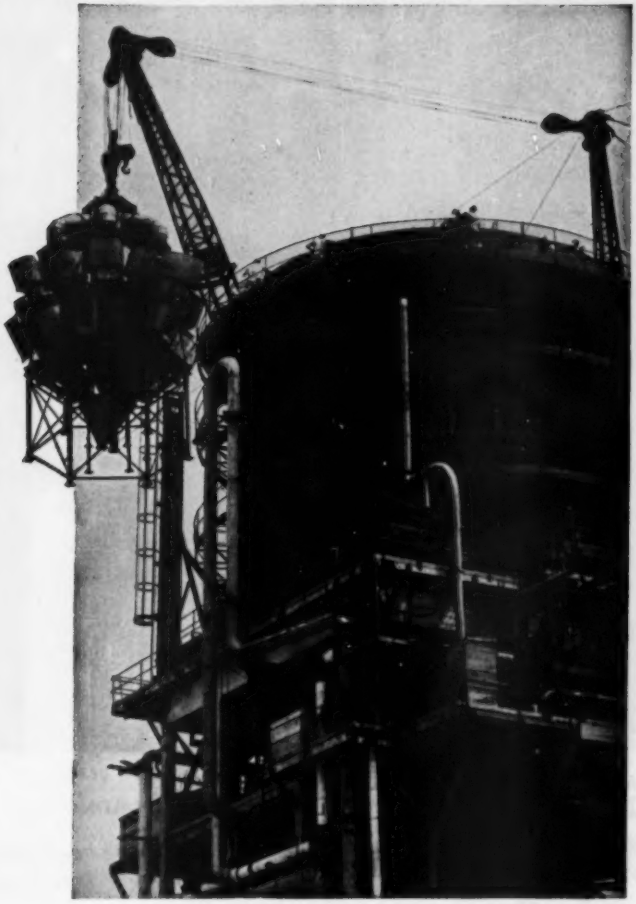


STOP FOR SAFETY
Reduce the hazard of injury to workmen or damage to equipment which might cripple vital production

STOP AND HOLD ANY LOAD
Unibrake motors are very advantageous on hoist, elevators, inclined conveyors, etc. . . .



BUELL IS TOPS
in catalyst recovery



In fluid or thermofor catalytic cracking Buell recovery systems have demonstrated continuous high-efficiency performance in all the major refineries. Design information is available on the latest multi-stage collectors. Buell Engineering Company, 70 Pine Street, Dept. 21E, New York 5, N. Y.

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Engineered Efficiency in
DUST COLLECTION

MANUFACTURING IN UNITED STATES AND CANADA FOR SHIPMENT THROUGHOUT NORTH AND SOUTH AMERICA

Patents

carbonylizing step by continuously passing a CO/H_2 mixture through a cobalt-containing mass in the presence of the liquid olefin reactant.

U.S.P. 2,588,123. Preparation of Vinyltetrahydronaphthalenes. E. A. Kern to General Electric Company.

Tetrahydronaphthalene is acetylated at a temperature of 40°-50° C. The acetylated product is reduced and the resulting carbinol is dehydrated. 8-Vinyltetrahydronaphthalene is obtained in increased yield.

U.S.P. 2,588,260. Oxidation Carrier for the Oxidation of Hydrocarbons. C. S. Lynch and E. S. Corner to Standard Oil Development Company.

An oxygen carrier for the production of synthesis gas from hydrocarbons consists of equal gravimetric proportions of iron oxide and manganese oxide and also contains 10-40 percent by weight of magnesia or chromium oxide.

U.S.P. 2,587,990. Manufacture of Detergents and Wetting Agents from Olefins. P. J. Garner and H. N. Short to Shell Development Company.

Olefin-containing hydrocarbons are reacted with a polybasic inorganic acid. The acid esters produced are neutralized. A portion of the remaining mixture freed of polymers formed and comprising unreacted olefins and secondary alcohols is contacted with a dehydration catalyst to convert this alcohol to the corresponding olefin. The olefinic product is reacted with a polybasic inorganic acid, and the resulting acid ester is neutralized. The yield of ester salts is thus increased.

U.S.P. 2,588,388. Oxidation of Alkyl Substituted Cyclohexanes Using Aldehyde Activated Catalysts. David C. Hull to Eastman-Kodak Company.

Methylcyclohexane is oxidized to cyclohexanoic acid by contacting it and a gaseous oxidizing medium with a catalyst comprising cobalt acetate in acetic acid solution which has been activated by the passage of air and acetaldehyde at 30°-60° C. Reaction temperatures of —5° to 90° C. are employed.

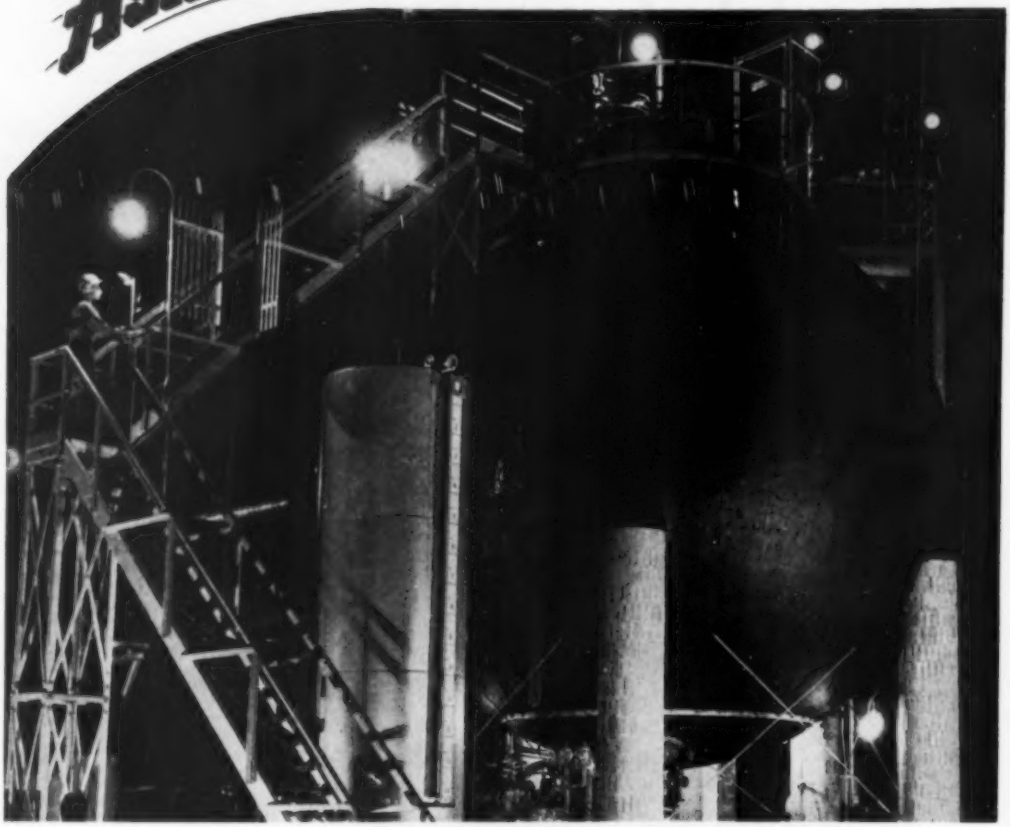
U.S.P. 2,589,648. Cycloalkane Oxidation. F. T. Wadsworth to Pan American Refining Corporation.

A liquid cycloalkane with 4-6 C atoms in the ring is oxidized in the liquid phase in the presence of a polyvalent heavy metal catalyst and cyclohexanone reaction initiator in a solution containing 10-70 percent acetone. Alkane dicarboxylic acids are produced, such as adipic acid from cyclohexane.

U.S.P. 2,590,124. Partial Oxidation of Hydrocarbons Using Gaseous Sulfur Trioxide. W. H. Reeder to Clark Brothers Company, Inc.

Saturated aliphatic hydrocarbon gases, e.g. methane, are mixed with SO_3 vapor in the absence of free oxygen. The mixture is contacted with an adsorptive carbonaceous, silicious, or aluminiferous catalytic material at a temperature of 175°-450° C. Partial oxidation of the hydrocarbon is obtained with formation of compounds containing the carbonyl

Ashland another leading refiner who desalts with PETRECO



The Ashland Oil and Refining Company and its affiliated companies are a fast growing and highly progressive organization. Like other leaders in the refining field, Ashland relies on Petreco Desalters to keep their crude charge free from harmful salts and solids. Like the many other experienced refiners who specify Petreco Desalting repeatedly, the Ashland group has installed Petreco in their refineries at Ashland, Kentucky; Canton, Ohio and Buffalo, New York.

Leading refiners such as the Ashland Oil and Refining Company have learned that Petreco Desalters consistently deliver high-efficiency performance, and are kept at this high performance level by helpful, dependable Petreco service engineers. **PETRECO OFFERS COMPLETE DESALTING SERVICE AND FACILITIES**

GET THE BEST IN DESALTING

Minimum residual salts and solids

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PR 51-6

group and hydrogen, such as formaldehyde.

U.S.P. 2,590,426. Process for Photochemical Chlorination of Hydrocarbons. A. Loverde to the U. S. Atomic Energy Commission.

Heptane is contacted under actinic light with chlorine diluted with an inert gas at a temperature rising gradually from 25° to 50° C. for 48 hours, and then with undiluted chlorine for 80 more hours at a temperature gradually rising to 150° C. The heptane is chlorinated to about 80 percent chlorine.

U.S.P. 2,590,810. Preparation of Vinyl Chloride. R. B. Young to General Electric Company.

Acetylene and HCl are passed in the vapor phase over a halide, sulfate, nitrate or acetate of copper adsorbed on carbon. Vinyl chloride is produced.

Skelly Tops One Million Man-Hours Safety Record

Skelly Oil Company employees at the refinery and lubricating plant at Eldorado, Kansas, have completed one million man-hours without a lost-time injury. In appreciation of the accomplishment, Skelly held a special celebration at Eldorado, awarding certificates of achievement to each employee who participated in crossing the one million man-hours goal.

BOOKS of Current Interest

Review and Comment for the Process Man

Kinetics, Reactions Tables

Tables of Chemical Kinetics, Homogeneous Reactions, National Bureau of Standards Circular 510, United States Government Printing Office, Washington, D. C., $4.

This circular presents a critically evaluated compilation of the available numerical data on rates and rate constants of homogeneous chemical reactions. Stress is laid throughout on experimentally ascertained facts, and data depending on interpretations are generally not included. Supplementary tables give additional useful numerical information. References are usually provided for secondary effects, in particular the great variety of salt effects, etc. In addition, the circular contains a list of references to literature in the field and some concise comments on a variety of additional items of information, both on the table as a whole and on particular reactions.

Thermodynamic Properties

Selected Values of Chemical Thermodynamic Properties, Frederick D. Rossini, Donald D. Wagman, William H. Evans, Samuel Levine, Irving Jaffe, National Bureau of Standards Circular 500, United States Government Printing Office, Washington, D. C., $7.25.

This volume contains values of the heat and free energy of formation, entropy, heat capacity, and heats and temperatures of transition, fusion, and vaporization for all inorganic compounds and organic compounds (containing not more than two carbon atoms), where such data are available. Separate tables give references to the original literature from which the values were derived. The introduction discusses units of energy and fundamental constants, definition of symbols, abbreviations and conventions regarding physical states, standard states, internal consistency, and order of arrangement of the chemical substances. An index to the tables is appended.

A-C Has Three Centrifugal Pump Films Available for Showing

Now available through Allis-Chalmers general machinery division district offices is the first in a series of a new educational service to industry in the form of three 35mm sound filmstrips on centrifugal pumps for showing before interested groups. Titles of the

DOES YOUR WATCHMAN *Hibernate* ON WEEKENDS?

Unless you pay someone to watch your Watchman on weekends—he is likely to emulate the bear and go into hibernation.

Would you like to save the overtime expense of paying a supervisory employe to return to the plant every Saturday and Sunday—just to change the dial in your Watchman's clock?

The answer is the DETEX GUARDSMAN Watchclock, which operates on continuous roll tape—for as long as 96 hours, if need be—without the necessity of cutting the tape. This means your Watchman is getting unbroken mechanical supervision on weekends, as well as during the week.

With the GUARDSMAN on the job, your Watchman is on the job—or you'll know the reason why in short order. The cost of the GUARDSMAN is trifling insurance against fire, theft and vandalism. The records show that more than 40% of companies which have disastrous fires never resume business.

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three films, each with a running time of about 30 minutes, are "How and Why of Centrifugal Pumps," "Pump Maintenance," and "Covering All Angles." Requests for showings of any of these filmstrips should be made to the nearest Allis-Chalmers general machinery division district office. Booklets describing the contents of the three films are available.

Minneapolis-Honeywell Wins 1951 Sales Achievement Award

The 1951 award for outstanding sales achievement, annually presented by the Sales Managers Association of Philadelphia, has been awarded to the Minneapolis-Honeywell Regulator Company, Sidney M. LeBair, president and chairman of the award committee has announced. Honeywell was selected for the 16th presentation of the award from a field of more than 30 entrants. The award, known as the Howard G. Ford Award, was inaugurated in 1937. Last year's winner was the Sylvania Electric Company. Honeywell, whose total sales for 1951 aggregated more than $135 million, a 24 percent increase over 1950, was cited for "progressive expansion policies and outstanding sales promotion techniques."

Hagan Corporation's Research Laboratory Nearing Completion

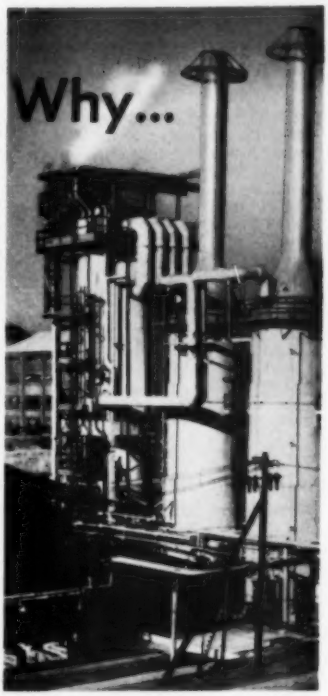
Development and testing of combustion and process control systems and instruments will be a major function of the new research and development laboratory now nearing completion at Hagan Corporation's Orrville, Ohio, plant. The new laboratory will be known as the "J. M. Hopwood Research Building" in memory of the founder of Hagan Corporation. In addition to the research and development work, instruction courses will be held there for engineers and operating personnel of industrial firms. Some of the laboratory facilities are already in partial use. No formal opening ceremony is planned.

Orbit Valve Makes Changes, Additions to Field Sales Staff

The following changes have been announced by R. G. Cole, general sales manager of Orbit Valve Company. Jack H. Hancock, who has been with the company since July of 1947, is being transferred to Casper, Wyo., as field representative in the Rocky Mountain area. Claude W. Brown is transferring to Chickasha, Okla., where he will take over Hancock's territory. Cole has also announced the appointment of James P. Bowling as city salesman for Houston. Bowling was formerly South Texas representative for Rector Well Equipment Company.

Morse Dial Elected President Of Union Carbide and Carbon

Morse G. Dial has been elected president of Union Carbide and Carbon Corporation, succeeding Fred H. Haggerson who continues as chairman of the board. Dial is a graduate of Cornell University and was elected executive vice president of Union Carbide in 1951. He joined the corporation in 1929, became assistant secretary and assistant treasurer in 1939, secretary and treasurer in 1945, vice president and director in 1949, and a member of the executive committee of the corporation in 1951.



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. . . because NATIONAL AIROIL Tandem Units are *more* than just combustion equipment. They are an *exclusive up-firing Combustion System* which has *proved* many more hours "on stream" without shutdown. "Airocoal" Tandem Combustion Units (firing dirty refinery gas; uncut asphalt; refinery fuel oils) hold air in the combustion zone until fuel and hot air are mixed thoroughly. This means that combustion takes place in a hot zone; the result . . . increased combustion efficiency with a minimum of excess air.

NATIONAL AIROIL Tandem Units average 16% further flame travel within a given furnace . . . allowing secondary air to be controlled easily and accurately . . . and flame can be regulated to uniformly radiate heat to the absorbing surfaces without *impingement*.

The Tandem Unit is popularly fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . has a high turn-down ratio with a steady flame . . . maintains high flame temperature with either fuel oil or gas; and can be brought quickly to full capacity with a clean fire.

You will realize higher profits from YOUR heaters when Tandem Combustion Units are specified.

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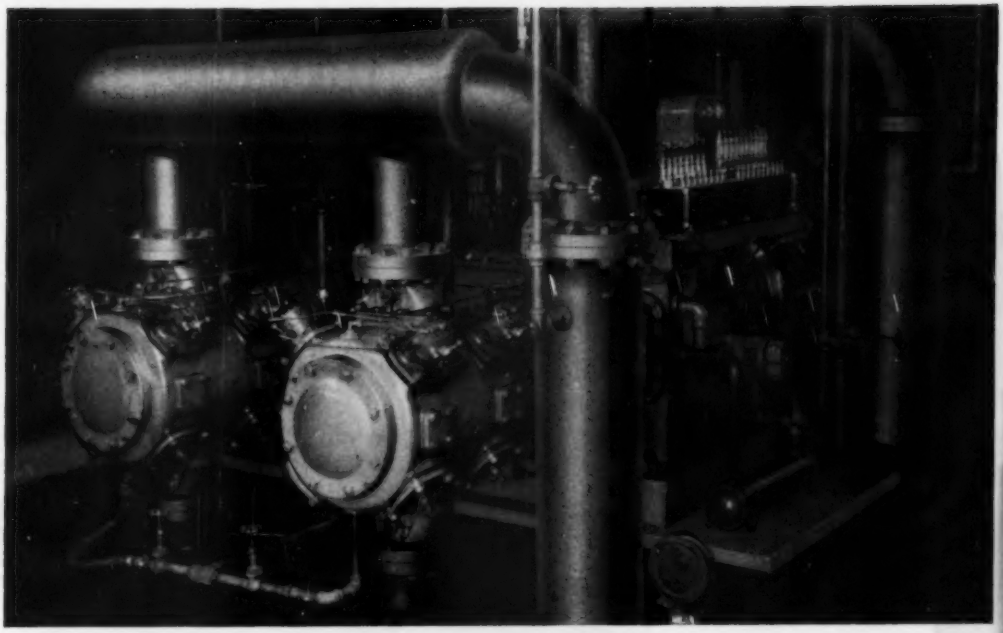
GAS BURNERS, FURNACE EQUIPMENT



SAVINGS... even before the word GO!

Great Lakes Refining selects the compressors that simplify erection and firewall installation

When Great Lakes Refining Co. was planning its new Houdriflow cat cracking unit at Blue Island, Illinois, one of the prime requirements was a low fire hazard compressor installation for vapor recovery service.

What type of compressor should be used? The decision was easy after Clark engineers made a thorough analysis carefully considering gas and steam engine driven units, motor driven reciprocating units and centrifugal compressors. Building all types of compressors, Clark was unusually qualified to make this comparison—*impartially!* Recommendation: Two Clark CMA-4, 300 bhp, Balanced/Opposed, Synchronous Motor Driven Compressors.

Of major importance was adaptability to firewall type construction. Having a single unit crankcase with the driving motor on the end, it would be a simple matter to isolate the motor from the Clark Balanced/Opposed Compressor. The shaft would merely extend through the firewall, with a simple packing gland sealing out the gas.

Costwise, Great Lakes Refining was ahead from the day the order was placed. Considerable time and cost in installation were saved by shipping the unit completely assembled. Vibration-free operation —*the result of perfect balance*— paid off in smaller foundation cost and will *continue* to pay off in practically maintenance-free operation.

For details on this truly modern compressor, write for Bulletin No. 118. For complete information on *all* your compressor problems, call in the nearest Clark representative for an unbiased answer.

•

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For Use in Refineries, Gasoline Plants, Chemical Plants, Ships, Barges and Pipelines

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Let us quote you on your fittings requirements.

Return Bend Fittings

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Why Beaird fittings are superior:

- **Heavier walls**
- **Completely backfaced flanges**
- **Concentric bores**
- **Uniform gasket surfaces**
- **True flange circumferences**

THE J. B. BEAIRD COMPANY, INC. **SHREVEPORT, LOUISIANA**

MACHINING
FABRICATING
STEEL WAREHOUSE

About EQUIPMENT and SERVICE Suppliers

Process Controls, New Division Of Baird Associates Formed

Walter S. Baird, president of Baird Associates, has announced the formation of Process Controls, a new division of Baird Associates. The new organization will devote its efforts to the applications of continuous process control equipment based on infrared analysis, and the further development of effective instrumentation in this field. S. H. Walters, chief engineer of Baird Associates, has been named executive vice president of the new organization, with George Oden in charge of development, and Joseph M. Devine in charge of sales and service.

UNIT MOVED—Welding equipment manufacturing of A. O. Smith Corp. has moved into this 27,000-square foot Milwaukee building from the Company's main Milwaukee works. Besides providing needed space for assembly lines for A. O. Smith's 12 basic welder models, the building also houses experimental shops and some sales offices. Space vacated at Milwaukee Works is being utilized for expanded welding electrode production.

National Lead Names Fowler, Bugbee To Advertising Posts

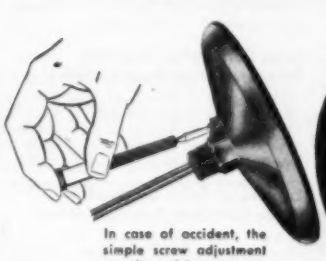
Donald T. Fowler has been named advertising manager of Baroid Sales division, National Lead Company in Houston, and James Bugbee, Jr., has been transferred to the advertising department to assist in the preparation of the firm's technical publications relating to oil well drilling muds, well logging and testing equipment. Fowler has been associated with the Axelson Manufacturing Company, Byron Jackson Company and was with the advertising department of Lane-Wells Company for several years before joining Baroid. A native of Oregon, he was educated at the University of Southern California. Bugbee has been with Baroid since 1947 and was educated at the University of Texas.

Fowler

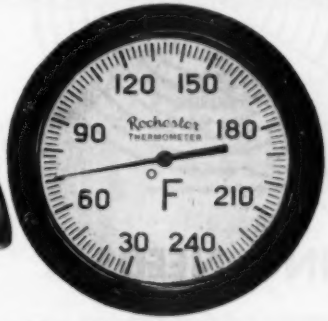
Bugbee, Jr.

Roots-Connersville Becomes Division Of Dresser Industries

Roots-Connersville Blower Corporation has been absorbed into the corporate structure of its parent, Dresser In-



In case of accident, the simple screw adjustment permits quick, easy, on-the-job recalibration.



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ROCHESTER DIAL THERMOMETERS are built to take severe blows without damage to their sensitive movements. But when hit hard enough to knock them out of adjustment, all you need is a screwdriver to put them right back on the job—as accurate as ever. This unique Rochester recalibration feature eliminates the danger of costly production errors due to inaccurate readings.

WELDED STAINLESS STEEL construction makes Rochester thermometers more durable, sensitive, pressure tight and resistant to corrosion than any before offered. Backed by 35 years of instrument making experience.

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COSTLY BREAK-DOWN AND REPLACEMENTS

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WHITON MACHINE COMPANY
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dustries, Inc., and will operate under the name "Roots-Connersville Blower," a division of Dresser Industries, Inc. The firm will continue to operate as a separate organizations with no changes in plant facilities or set-up.

Shell Chemical Names Huldrum To Position of Sales Manager

George W. Huldrum, Jr., has been appointed to the new position of sales manager of the Western division of Shell Chemical Corporation. Huldrum began his career as a chemist at Shell Chemical's Pittsburg, Calif., plant in 1939, after completion of studies at the University of California. In his new position, Huldrum heads sales activities in ammonia and ammonium sulphate fertilizers, solvents for protective coatings, plastics and resins, and insecticides.

Carborundum Promotes Killmar To Assistant Works Engineer

The Refractories division of The Carborundum Company has announced the promotion of H. M. Killmar to assistant works engineer for the division. Killmar joined Corborundum in 1947 as a planning and project engineer, and then advanced to senior sales engineer. A graduate of the University of Illinois, he has worked with Atlantic Terra Cotta Company and with the General Chemical division of Allied Chemical & Dye Corporation.

Brown Joins Power Chemicals Division of E. F. Drew Company

The Power Chemicals division of E. F. Drew & Company, Inc., has announced that F. W. Brown has joined their organization. Brown, who formerly was with Chemical and Carbon Products, Ltd., and I.C.I. Ltd. in London, will be sent, after a training period in the United States, to Sao Paulo, Brazil, where he will be in charge of Water Treatment for E. F. Drew & Cia, Ltd.

Sulcer Elected Vice President Of Graver Tank & Manufacturing

Henry T. Sulcer, general manager of the Graver Water Conditioning Company has been elected a vice president of the parent Graver Tank & Manufacturing Company, Inc. Sulcer has directed the activities of Graver Water Conditioning Company since its establishment in separate headquarters in New York. He had served earlier as general auditor for all divisions of Graver. Previously, he had been vice president and general manager of a Chicago manufacturer of industrial heating equipment. He is a graduate of the University of Chicago School of Commerce and also the University of Chicago School of Law.

Sulcer

J. M. McNamee Named American Cyanamid Sales Representative

J. M. McNamee has been appointed sales representative for American Cyanamid Company's Industrial Chemicals division in the Georgia and Florida district and will operate out of Atlanta. Joining Cyanamid in 1950, McNamee is a graduate of Tufts College.

Selas Corporation Appoints Schneider Sales Representative

William C. Schneider has been appointed sales representative by Selas Corporation of America, heat processing engineers. His territory will include central and western New York state.

Equipment Sales Corporation Made Conoflow Representatives

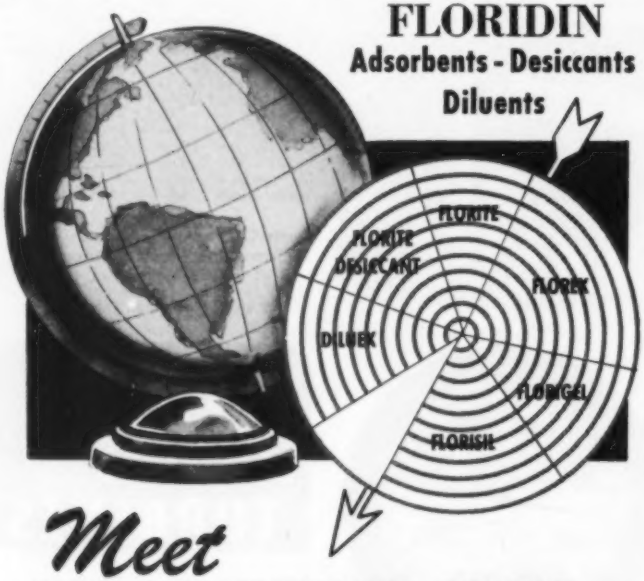
Vice President John C. Koch of the Conoflow Corporation has announced the appointment of the Equipment Sales Corporation as representatives serving eastern and central Tennessee as well as southwestern Virginia with Conoflow pneumatic control equipment.

New Sales Assignments Made At Maxwell, Manning & Moore

Raymond C. West and George F. Bright have been assigned to new district manager positions for Manning, Maxwell & Moore, Inc. West becomes Gulf Coast district manager with headquarters in Houston, while Bright has been made manager of the Mid-Continent district wtih headquarters in Tulsa, Okla.

Taylor Instrument Companies Names Skrokov Sales Engineer

After completing a training course at the home office in Rochester, N. Y., Robert Skrokov recently joined the New York office of the Taylor Instrument Companies in the capacity of industrial sales engineer. Skrokov received a de-



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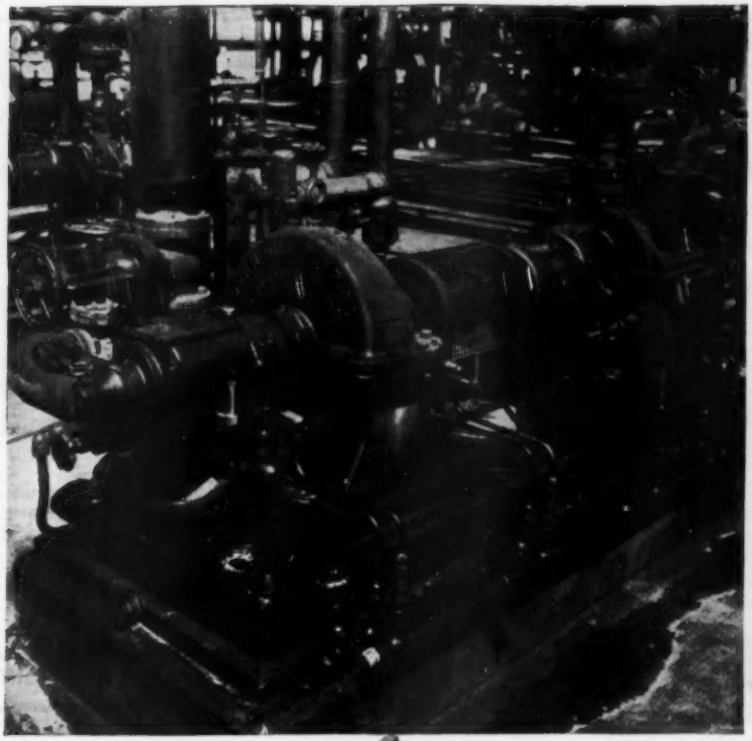

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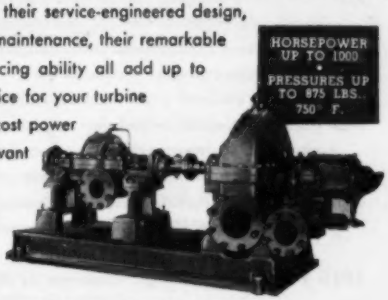
are single stage, double impact type for low steam consumption. Specifically designed for operation at medium steam pressures and temperatures, DH Turbines have all the advantages available under these conditions, including excellent water rates. Get the full details and complete specifications. Write today.

POWERFUL "PENNY PINCHER"

Power a-plenty at a penny-pinching cost! That's how DEAN HILL STEAM TURBINES operate. Their super rugged construction, their service-engineered design, their low maintenance, their remarkable power-producing ability all add up to far more service for your turbine dollar. If it's low cost power you want . . . you want DEAN HILL STEAM TURBINES.



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Proved long life and stubborn resistance to corrosion make cast iron pipe a contributing factor in lowering plant maintenance per barrel of crude. Replacing shorter-lived pipe with cast iron pipe has demonstrated this in many refineries. Cost per term of service decreases. Interference with production, caused by frequent replacements, ceases to be a headache. Cast iron pipe works hand-in-glove with plant management to keep maintenance cost down in many refinery operations. Available with bell-and-spigot, plain end and flanged, or with standardized mechanical joints. Cast Iron Pipe Research Association, Thomas F. Wolfe, Engineer, 1015 Peoples Gas Bldg., Chicago 3, Illinois.

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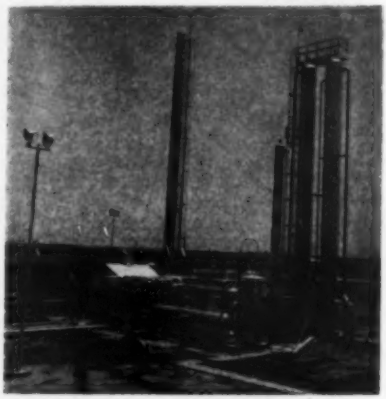

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AMARILLO, TEXAS

gree in mechanical engineering from the College of the City of New York. He served in the U. S. Navy and for two years was a development engineer in the oil industry.

Vulcan Copper Organizes Four Separate Operational Divisions

In beginning its fifty-first year of business, The Vulcan Copper & Supply

Gould Cunningham Kline

Company has announced the organization of the company's operations into four separate divisions, each one functioning independently of the other. The Vulcan Engineering division headed by V. D. Drummond carries on its services by offering expanded facilities for technical and economic surveys, process development, process and plant design, equipment design and procurement, over-all erection and construction supervision, plant start-up and initial operation. The Vulcan Manufacturing division under the direction of P. W. Wentworth will continue in the engineering and fabricating of distillation, evaporation and extraction equipment. The Construction division, temporarily managed by Thomas Carroll will perform contracts for the erection of chemical plants and the installation of processing equipment. The Industrial Supply division operates its service of warehousing and distributing tools, factory supplies, copper, brass and alloy products. E. E. Wentworth is manager of this division.

The company has also announced three recent appointments to key positions: Merle L. Gould as chief development engineer, George F. Kline as project engineer, and F. Corson Cunningham as process engineer.

American Shoe Brake Company Purchases Jumbo Steel Plant

American Shoe Brake Company has purchased the plant and property formerly owned by the Jumbo Steel Company in Azusa, Calif. The property consists of approximately five acres of land and several buildings. The American Forge division of Brake Shoe will use the plant to start a west coast steel forging operation.

Consolidated Engineering Names Dr. Berry In Research Promotion

Dr. Clifford E. Berry, nationally known authority in the field of mass spectrometry, has been promoted to the office of assistant director of research at Consolidated Engineering Corporation of Pasadena, Calif. Dr. Berry's particular distinction derives from his development of the Isatron, considered the heart of the mass spectrometer, and perfecting the Diatron, a pocket-size ion source for use in the Leak Detector.

A native of Iowa, he received B.S., M.S., and Ph.D. degrees from Iowa State College and holds several patents relating to mass spectrometry. He also

Better on "1001" Pumping Duties

Capacities to 150 G.P.M.

Heads to 500 Ft.

APCO Two-Stage Turbine Type Pump for High Pressure Service

Apco—the pump with but one moving part, the impeller — is famous for long-lived, efficient performance on small capacity, high head duties. Available in Single Stage, Two Stage and 4-Stage Tandem for high pressures — and Water Jacketed for high temperature and highly volatile liquids.

Write for Bulletins 111, 111-A, 111-WJ

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AURORA Always PUMPS — AURORA PUMP COMPANY

BLAW-KNOX GRATING

Electroforged into rigid, one-piece panels.

Twisted cross bar prevents slipping.

...GIVES BETTER SERVICE ON 5 COUNTS

1 SAFER FOOTING
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Bring your open steel flooring problems to Blaw-Knox for expert help. Bulletin 2365 sent on request.

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BLAW-KNOX *Electroforged* STEEL GRATING

let's take a CLOSER LOOK at STRESS RUPTURE

In evaluating the suitability of various tubes for high pressure, high temperature applications, consideration of their stress-rupture properties is of major importance to avoid misapplication and consequent possibility of costly service failures.

B&W's long experience with tubing applications in the petroleum and chemical processing industries, where stress and temperature conditions often are acute, has led B&W to conduct complete, analytical stress-rupture tests far exceeding conventional practice so as to answer the most exacting questions of tube applications in modern processing conditions.

In essence, the stress-rupture test is an overloaded creep test which is continued to actual failure of the specimen. Destructive testing of this kind acknowledges theoretical approach, but at the same time circumvents it by simulating the worst possible conditions that would likely be encountered in actual service. Through such long-term tests extrapolation is reduced to the minimum with the result that possibility of error in determining stress-rupture limits of tubing materials is minimized.

From curves like those shown above and other available stress-rupture data, it is possible to closely determine: (1) the amount of extension, or elongation, various metals will stand under given stress and temperature conditions before rupture occurs, (2) how long various metals can be overheated under given stress without failing due to rupture.

Investigation of stress-rupture properties of tube-steels is a continuing activity at B&W. Facilities devoted to this purpose are among the most extensive available anywhere.

If rupture strength is your tube problem, consult Mr. Tubes—your B&W Tube Representative. Available through him is a wealth of experience and technical data on the behavior of carbon, alloy, and stainless steel tubes at elevated pressures and temperatures.

Shown above are some of the stress-rupture data available on B&W Tubes. Copies will gladly be supplied to anyone concerned with the design, operation and maintenance of tube installations in high pressure, high temperature services.

B&W SEAMLESS and WELDED TUBES

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
General Offices & Plants
Beaver Falls, Pa.—Seamless Tubing; Welded Stainless Steel Tubing
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Sales Offices: Beaver Falls, Pa. • Boston 16, Mass. • Chicago 2, Ill. Cleveland 14, Ohio • Denver 1, Colo. • Detroit 26, Mich. • Houston 2, Texas • Los Angeles 17, Cal. • New York 16, N. Y. • Philadelphia 2, Pa. • St. Louis 1, Mo. • San Francisco 3, Cal. • Syracuse 2, N. Y. Toronto, Ontario • Tulsa 3, Okla.

TA-16335

has had many papers published along these lines.

The initial design of the Consolidated Electrical Computer for the solution of 12 simultaneous linear equations is considered one of Dr. Berry's outstanding accomplishments, and he played a large part in the completion of the engineering design of the Consolidated-Nier Isotope Ratio Mass Spectrometer.

Dr. Berry joined Consolidated Engineering Corporation in 1942 as Research Physicist, and lives in Altadena with his wife and two children.

Craven Appointed Manager of Davison's Lake Charles Division

Henry E. Craven, Jr., has been appointed manager of the newly organized Lake Charles division of The Davison Chemical Corporation. The new division will operate the large plant which the company is building on the Calcasieu River south of Lake Charles, La., and which will produce petroleum cracking catalyst and other chemicals. Prior to joining Davison in 1951, Craven was plant manager of Pemco Corporation in Baltimore. He is a graduate in ceramic engineering of North Carolina State College. Craven was with Pemco in Baltimore before the war and saw service from 1942 to 1946 as a captain in the Army Chemical Corps.

Craven

Clark Equipment Truck Division Names New Regional Sales Head

The appointment of Vernon L. Johnson, associated until recently with the Studebaker Corporation, as regional sales manager has been announced by the Clark Equipment Company. Johnson will head up Clark's northeastern region and will make his headquarters in New York. He is a graduate of the University of Illinois.

Steinkamp Appointed To Head Honeywell Industrial Sales

Minneapolis-Honeywell Regulator Company has announced the appointment of William H. Steinkamp as sales manager of the industrial division after serving as industrial field sales manager since 1943. He succeeds L. Morton Morley, who continues as vice president of the Brown Instruments division. A graduate of New York University in 1928, Steinkamp joined the Brown division in 1930 as field sales engineer.

Watson-Stillman Announces Multiple Executive Changes

The following recent changes in Watson-Stillman executive positions have been announced:

R. S. Sweeney, vice president and treasurer, has been elected a director. James W. West, Jr., a director, has been appointed assistant to the president. A. B. Diss has been appointed vice president of manufacturing; R. W. Dinzl, consulting engineer; Adolph deMatteo, chief engineer; R. W. Schreck, general manager of sales, Hydraulic Division; Jackson Kemper, general manager of

NEW HEAT SAVING EFFICIENCY

- Longer Life
- Custom Molded Precision Pipe Fit
- Attractive, Smooth Finish

Now available in pipe covering and block insulation, Mundet 85% Magnesia permits new heat-saving efficiency. Precision manufacturing on the latest type of automatic equipment insures uniform standards. Extra durability is built into the insulation. It does not "powder", settle or disintegrate. It is unaffected by either steam or water leakage. It maintains an attractive, smooth finish. Precision pipe fit is assured, with no spaces left for the escape of heat. You benefit from the most modern manufacturing facilities for the production of heat insulation. Write for specification information and recommendations. Mundet Cork Corporation, Insulation Division, 7101 Tonnelle Avenue, North Bergen, N. J.

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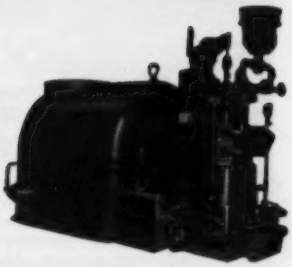

• Available with from two to ten pressure stages. Horsepower range from 100 to 4000, steam pressures up to 600# ga., 750° F., condensing or non-condensing. Optional governor equipment and accessories adapt UV Turbines to any mechanical drive within their capacity range.

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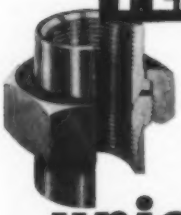

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a type for every use . . . all temperatures, all pressures!

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Experience in meeting the exacting requirements of our military contracts is a guarantee to customers of our ability to meet highest standards in all types of non-ferrous and special alloy fabrication. Heliarc and "sigma" semi-automatic inert gas welding for the latter mean special qualifications to meet the most exacting requirements.

WARNER LEWIS COMPANY

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sales, Distributor Products Division; Herbert E. Elliott, sales manager, Hydraulic Division; John P. Bittenbinder, sales manager, Distributor Products Division; Walter R. Biedermann, Industrial engineer; Elsworth Falkenberg, plant manager; Eric Nelson, plant superintendent; A. Walters, production manager, Hydraulic Division.

In addition Richard M. Norman, a graduate of Georgia Tech has been added to the Hydraulic Sales Department.

Boynton Named District Manager For Western Canada by Tube Turns

Harry E. Boynton has been named as district manager for Western Canada by Tube Turns of Canada, Ltd. Born in Toronto, Ontario, Boynton obtained his degree in mining engineering at the University of Toronto and began his career on the engineering staff of The International Nickel Company of Canada, Ltd. Before joining Tube Turns, he was chief engineer of the Eldorado Mining & Refining Ltd. and was stationed at Port Radium. Boynton is a member of the Association of Professional Engineers of Ontario and Phi Kappa Pi. During World War II, he served with the Canadian Navy on convoy duty in the North Atlantic.

Boynton

Gar Wood Industries Names Dries Advertising Manager

Gar Wood Industries, Inc., has appointed Arthur F. Dries manager of sales promotion and advertising. Dries is in charge of the corporation's central advertising department which handles functions for the Findlay, Wayne, St. Paul, Richmond and National Lift Divisions as well as the Gar Wood branch offices in major cities throughout the country.

Dries was formerly sales promotion manager for Service Supply Corporation, Philadelphia, and advertising manager for Hose Accessories Company, Philadelphia, and spent several years with the Koehring Company, Milwaukee.

Pacific Pumps' European Survey Checks Product Performance

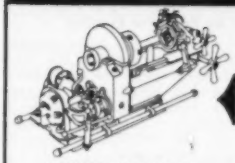
Ernest W. Wilhelm recently returned from a 12-month tour of major refineries in Great Britain and continental Europe in the interest of Pacific Pumps, Inc., Huntington Park, Calif. He reported operators in all countries visited, expressed great satisfaction with both American-made Pacific pumps as well as foreign made Pacific pumps fabricated under Pacific license.

Wilhelm also spent considerable time consulting with the heads of Pacific's licensees in Reading, England; The Netherlands; and Batignolles Chatillon, France.

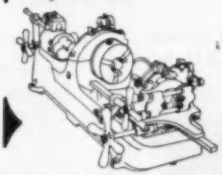
Minneapolis-Honeywell Names Wilson to Field Sales Post

O. B. Wilson has been made field sales manager for the Industrial Division of Minneapolis-Honeywell Regulator Company, succeeding William H. Steinkamp who was recently made general sales manager of the division. Wil-

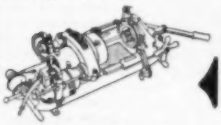
BEAVER—gives you a choice of 4 PIPE and BOLT MACHINES



BEAVER MODEL-A
A rugged, Heavy-Duty Machine. Range ⅛ to 2". Up to 12" with Geared Tools and Drive Shaft. Bolts ¼ to 2"—Weight 365 lbs.

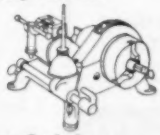


BEAVER MODEL-B
A Middleweight Utility Machine. Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 235 lbs.



BEAVER MODEL-E
A Lightweight Portable Machine. Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 185 lbs.

BEAVER MODEL-C1
A sturdy little Power Drive that converts Hand Tools into Power Tools—Range ⅛ to 2". Up to 8" with Geared Tools and Drive Shaft. Bolts ¼ to 1½"—Weight 140 lbs.



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For 70 years we've been weaving Wire Mesh. And a good part of that time we have also been making things of Wire Mesh for people who find it is cheaper, easier and generally more satisfactory to "let Jelliff do it."

From big Dipping Baskets to tiny precision filters — from fuel strainers to what-is-it gadgets — JELLIFF'S Custom Production Department turns out fabricated Wire-Mesh products at speed, price and precision that mean lower costs and a stronger competitive position for our many customers.

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DIPPING BASKETS · LEKTROMESH · RESISTANCE WIRE
WIRE MESH PARTS · WIRE CLOTH · STRAINERS • FILTERS
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There's an SD Pump for every asphalt handling job . . . in capacities from 2 GPM to 3000 GPM . . . plain or steam jacketed. Send coupon for complete details. KINNEY MANUFACTURING CO., Boston 30, Mass. Representatives in New York, Chicago, Cleveland, Houston, New Orleans, Philadelphia, Los Angeles, San Francisco, Seattle, and foreign countries.

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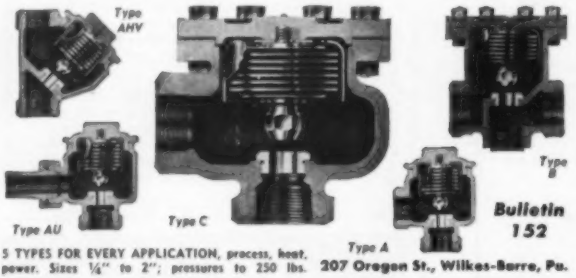
SAVE 10% IN STEAM COSTS

Chief Engineer H.F.D. stated, after Nicholsons replaced mechanical traps in his plant: "Saving in steam waste cut our fuel cost at least 10%. Yet application temperatures were up 30°-40°. And relief of all air binding effected faster warm-up."

Operate on lowest temperature differential; 2 to 6 times average drainage capacity; maximum air venting. For other advanced Nicholson features send for Bulletin 450.



Bulletin 152

5 TYPES FOR EVERY APPLICATION, process, heat, power. Sizes ¼" to 2"; pressures to 250 lbs.

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W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS

for Better Control and Shut-Off

of Air • Gases • Liquids • Solids

Better choose Rockwell Butterfly or Slide Valves. You get commercially tight shut-off in any metal construction; drip or air-tight in rubber-lined metal valves. You can have any manual or automatic control mechanism. Pipe size up to 72"—and larger. High or low pressure or temperature. Easy to install and service. Write for Catalog.

"Kwikfeen" slide valve with air cylinder operator; for handling carbon shapes in a hopper feed system.

Butterfly valve with electric motor and declutching mechanism for emergency handwheel operation; for handling water at 25 p.s.i.

Stainless steel butterfly valve for welding into pipe line; with air diaphragm operator and valve positioner; operation at 1600° F.

ROCKWELL VALVES

W. S. ROCKWELL CO. • 250 Eliot St., Fairfield, Conn.

son will supervise all industrial field sales and service personnel for all Industrial division products. Wilson joined the Brown division in 1923.

Ploch Named Sales Application Engineer By Reliance Electric

Harold A. Ploch has been appointed sales application engineer in the Southwestern district sales office of the Reliance Electric & Engineering Company. A Texan by birth, Ploch joined the Reliance organization in 1951, following three years with William Orrison Engineers and Associates.

Juraschek, Monnett Promoted By United States Steel Company

Appointments of Francis Juraschek as assistant director of distribution and availability and of Albert A. Monnett, Jr. as assistant director of commercial research (markets) has been announced by the United States Steel Company. Juraschek started his business career with McGraw Hill Publishing Company in 1915, holding a number of executive positions before joining U. S. Steel in 1939. Monnett is a graduate of the University of Idaho and of Harvard Business School. He joined the company as a market analyst in 1946, after serving as captain in the Army air force during the war.

Rockwell Manufacturing Names Two District Sales Managers

The appointments of M. D. Gilbert as Kansas City district sales manager and

Bush

Gilbert

Roy R. Bush as Tulsa district sales manager have been announced by Rockwell Manufacturing Company. Gilbert is a member and past director of the Southern Gas Association and served on its advisory council. He also belongs to the American Petroleum Institute, American Water Works Association and is a member and past president of the Tulsa chapter of Nomads. Bush joined the Rockwell sales staff in 1934 and became special sales representative for the company's Nordstrom Valve division before being appointed sales manager of oil field products.

Niagara Filter Names New Agents In New York-New Jersey Areas

Erhardt R. Bach and Fred E. Herstein have been appointed sales and engineering representatives for Niagara Filter Corporation. Bach will serve metropolitan New York, Long Island, southeastern New York and western Connecticut areas from the permanent office located at 59-32 Parsons Boulevard, Flushing, Long Island. Herstein will represent Niagara Filters in northern New Jersey and southeastern New

York. Bach previously served as sales engineer with the Buflovak Equipment Division of the Blaw-Knox Company, and Herstein has been operating for the past year and a half as a chemical equipment sales representative.

G. W. Huldrum Promoted To Sales Manager By Shell Chemical Corp.

Shell Chemical Corporation has announced the appointment of G. W. Huldrum as sales manager of the western division. He will head sales activities in ammonia and ammonium sulphate fertilizers, solvents for varnishes and lacquers, and plastics and resins. Huldrum began his career as a chemist at Shell Chemical's Pittsburg, Calif., plant in 1939 after completion of studies at the University of California. He progressed through various manufacturing and marketing assignments in California, Texas and New York and in 1947 was appointed district manager of the Detroit sales office. In 1951 he became assistant sales manager of the western division.

Huldrum

McCracken Is Manager Of New Rocky Mountain Sales District

Raymond R. McCracken has been named district manager of a new sales district formed by The France Packing Company. He will cover northern New Mexico, Colorado, Utah, Wyoming, Idaho and Montana, operating out of a Denver office. McCracken has worked for several years in that region. Until recently he was a district manager operating out of Chicago for the Raybestos-Manhattan Company. The France Packing Company is a manufacturer of metallic packing, power piston rings, bakelite compressor rings and valve discs.

McCracken

Grosselfinger Appointed to Advise Nitrogen Company

Frederick R. Grosselfinger has been appointed technical director by the Synthetic Nitrogen Products Corporation, New York, makers of "Cal-Nitro" and importers of potash from western Germany.

A graduate of Massachusetts Institute of Technology, in chemical engineering in 1939, he went with The M. W. Kellogg Company where he was employed in the process engineering department. In 1941 Grosselfinger joined the Signal Corps, and served five years in the Army as battalion commander and then Chief Signal Officer of the Rome Allied Command.

He was Knighted in the Order of Crown of Italy by King Umberto and was awarded the Bronze Star by the United States.

Upon separation from the Army,

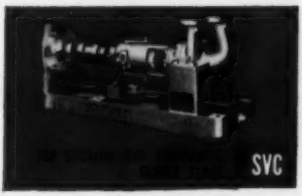
Like the Process Plants they serve

PACIFIC *Precision Built* PUMPS

are designed and built to operate on 24-hour seven-day-a-week schedule

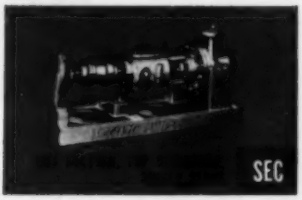
✔ **To Engineers responsible for the purchase of plant equipment**

Pacific Process Pumps are heavy duty pumps designed to fit your plant—and are fabricated from materials selected for the specific liquid to be pumped.



✔ **To Engineers responsible for operation and maintenance of plant equipment**

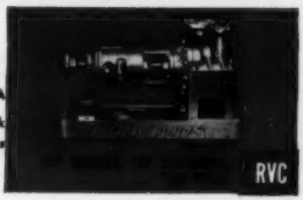
Pacific Process Pumps are heavy duty pumps with *EXTRA QUALITIES* built in—qualities of workmanship and materials that prevent painful loss of production and keep maintenance costs down.



✔ **To the Owner of the plant**

The value of the *EXTRA QUALITIES* built into Pacific Process Pumps is proved by their performance. The following performance record is typical of hundreds of installations: LIQUID PUMPED—*hot abrasive slurry;* TIME ON STREAM—*26,640 hours;* AVAILABILITY—*100%;* PARTS REPLACED AFTER *26,640* HOURS OPERATION—*wearing rings and shaft sleeves in each pump, impeller in one pump.*

Pacific Pumps inc.
ONE OF THE DRESSER INDUSTRIES
HUNTINGTON PARK, CALIFORNIA
Export Office: Chanin Bldg., 122 E. 42nd St., New York
Offices in All Principal Cities



CP-5

Grosselfinger joined Hydrocarbon Research, Inc. in New York and worked on process development and sales engineering, devoting one year to work with the Atomic Energy Commission.

Donald Dixon Named Service Representative in Denver Area

Donald E. Dixon, former power and maintenance engineer for various Colorado municipal and industrial power plants, has been appointed service representative for Hagan automatic combustion controls and Hall water treatment in the Denver district. For the past two years Dixon has served as chief engineer of the Trinidad, Colo., municipal power plant. During World War II he was a line engineering officer aboard tankers.

Fire Fighting Film Released By Walter Kidde & Company

"Not Too Hot To Handle," a new 18-minute, color, sound film has just been released by Walter Kidde & Company, Inc. The picture demonstrates approved fire extinguishing equipment and procedures for Class A, B, and C fires. During the film, professional technicians use all recognized types of portable extinguishers. Wood, flammable liquid, and electrical blazes are put out in seconds by the application of the proper extinguisher in an approved method. The new film is available nationally through any of Kidde's six district offices (Chicago, Detroit, Philadelphia, Dallas, Atlanta, Los Angeles), or upon request to any Kidde distributor.

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Robert A. Hunt Made Assistant Chief Engineer at Rochester

Robert A. Hunt of the engineering staff of the Rochester Manufacturing Company, Inc., has been appointed assistant chief engineer. Hunt, who has been handling special development work and design for the company for the past five years, will specialize in design and development problems in connection with electrical instruments for the indication of liquid indication of liquid level, pressure and temperature. The company is inaugurating an extensive research and development program on electrical instruments for the tractor industry under the general supervision of R. A. Tollefsen, chief engineer.

Hunt

Rust-Oleum Corporation Names Five Industrial Distributors

The Rust-Oleum Corporation has announced the addition of five new industrial distributors to its distributor sales organization throughout the country. The new firms appointed are: The Adkins Company, Berlin, Md.; Mill and Contractors Supply Company, Wilmington, N. C.; The Warren Hardware Company, Warren, Ohio; American Radiator and Standard Supply Corporation, Zanesville, Ohio; Couch and Heyle, Peoria, Ill.; The Republic Supply Company of California, Los Angeles, Calif., and Buhl Sons, Detroit, Mich.

Charles J. Uthoff Appointed Sales Engineer By Wedgeplug

The appointment of Charles J. Uthoff as regional sales engineer for the southwestern district has been announced by the Wedgeplug Valve Company, Inc. Uthoff, who is a graduate of the College of Engineering, Tulane University, and who received his M.S. degree in the same field from Louisiana State University, is an experienced sales engineer. As special factory representative, he will work closely with the Alfred Kent Company, Houston, and Harris Pruitt, Fort Worth, Wedgeplug sales representative in that area.

Uthoff

Colby Appointed Plant Manager Of Shippers' Car Line Firm

Ernest H. Colby has been appointed manager, plant operations, of Shippers' Car Line Corporation, subsidiary of the American Car and Foundry Company, with headquarters in New York. Colby was with Combustion Engineering—Superheater Company, Inc., from 1935 to 1938. From 1938 until his present appointment to Shippers' Car Line Corporation, he served as production manager of Riley Stokes Corporation in Worchester, Mass., and Cornwells Heights, Pa.

Saunders Named Sales Head Of Kinney Manufacturing Company

Harold G. Saunders, formerly district sales manager of the Philadelphia office of Kinney Manufacturing Company has been appointed sales manager of the company and is now located in Boston. Saunders joined Kinney in 1919 and served as salesman successively in St. Louis, Kansas City and Dallas. Since 1942 he has been with the Philadelphia office.

Saunders

Capron Named Chief Engineer B&W Tubular Products Division

Adin B. Capron has been named to the newly created post of chief engineer of the Tubular Products Division of The Babcock & Wilcox Company. Paul J. Utnehmer, works manager of the division said that because of an extensive expansion program under way at both the Beaver Falls, Pa. and Alliance, Ohio, plants a number of engineering functions at both plants have been centralized under the new position. Capron's headquarters will be at Beaver Falls and he will direct the activities of drafting, engineering development, maintenance, combustion and methods engineering groups and be in charge of all plant construction.

Graduated from Brown University with a degree in mechanical engineering, Capron has been with B&W since 1937, serving first as assistant superintendent of hot mills, and most recently as superintendent of tube mills at the Beaver Falls plant. Prior to 1937 he was associated with St. Joseph Lead Company.

David Faulkner, Industrial Tools Veteran, Retires Soon

David S. Faulkner, vice president of The National Supply Company will retire soon from a career in sales engineering that led him to many foreign countries as well as the major oil fields within the U. S. His first association was with the Otto Engine Works of Philadelphia, first manufacturers in the U. S. of the four-cycle internal combustion engine. Next he joined the Union Tool Company which later became part of The National Supply Company, and has been active in that organization since 1918.

Honeywell Names Stephen Keller Valve Division General Manager

Stephen A. Keller has been named general manager of the Valve Division of Minneapolis-Honeywell Regulator Company, succeeding James H. Binger, who will continue as vice president of the division. Keller will have full responsibility and authority for all phases of the division's activities with the exception of sales, and will coordinate sales projects with production, engineering and orders. K. R. Knoblauch will continue to direct sales activities.

Keller joined the Valve Division in February, 1951, having previously been with Wright Aeronautical Corporation

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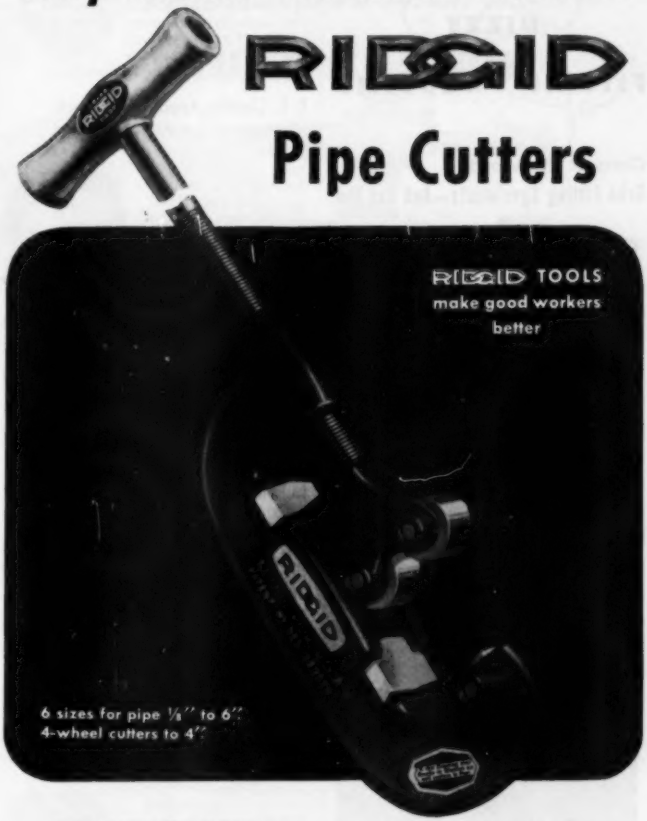
RIDGID

Pipe Cutters



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★ High alloy thin-blade cutter wheels roll quickly through pipe with least effort—clean, almost burrless cuts.

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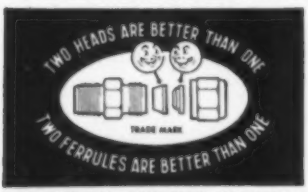


COME TO YOU COMPLETELY ASSEMBLED, FINGER TIGHT

for 10 years. While with Wright he held supervisory positions in manufacturing and industrial engineering.

Howard MacDonald, who has been chief industrial engineer, succeeds Keller as the division's plant superintendent. Robert W. Devenport, succeeds MacDonald as chief industrial engineer.

E. L. Lindsey Appointed Branch Manager of Los Angeles Office

Lindsey

E. L. Lindsey has been appointed Los Angeles branch manager for the Pump Division, Byron Jackson Company. Lindsey graduated from the University of Oklahoma in 1942 and took an additional two-year course at the Spartan School of Aeronautics at Tulsa, Okla., before becoming affiliated with Byron Jackson Company in 1944 in the position of sales engineer. He is married and will make his home in Los Angeles.

Lukens Steel Promotes Funk

William H. Funk, who has been associated with the Development Engineering Department of Lukens Steel Company since its inception in 1945, has been named assistant manager of the department. Funk has been connected with Lukens and its Lukenweld machinery making division since 1939, following his graduation from Drexel Institute of Technology, Philadelphia.

Fire Equipment Manufacturers' Group Elects McKesson President

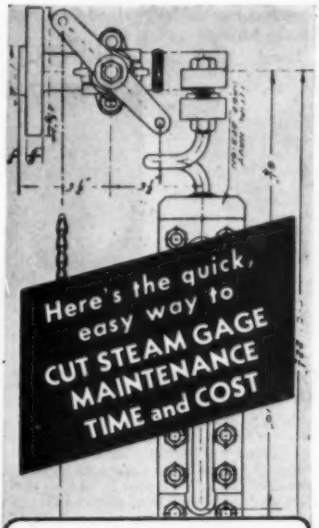
L. C. McKesson, vice president in charge of sales of the Ansul Chemical Company has been elected president of the Fire Equipment Manufacturers' Association. Other appointments of officers for the association were: first vice president, P. W. Eberhardt, vice president of Walter Kidde & Company; second vice president, H. Lewis Stettler Jr., executive vice president of Elkhardt Brass Manufacturing Company; treasurer, Paul Nurkiewicz, vice president of Stop Fire Inc. and commissioner R. Kennedy Anson.

McKessen

Pipe Manufacturer Announces Increase in Sales Personnel

South Chester Tube Company recently increased its sales forces in the Southwest and Midcontinent districts by adding the following personnel:

Thomas L. Vance has been assigned to the Ft. Worth office located at 307 Life of America Building; Ivan M. Fischer has been named to the Houston office in the Niels Esperson Building; Robert E. Wallace, Jr., has been transferred from the east to headquarters for the Midcontinent in Hutchinson, Kans.



Install Labor-Saving JERGUSON STEAM GAGE UNITS

. . . with gage and valves furnished as integral unit . . . without gage connection stuffing boxes or end stems.

JERGUSON Steam Gage Units, with gage and valves fabricated as a complete working unit will help you eliminate a lot of your maintenance time and troubles.

Especially designed to cut maintenance time, these complete units have no gage connection stuffing boxes to take care of and no end stems to cut or wire draw.

Gages and valves are an integral unit and have special expansion coils to take care of expansion and contraction. Transparent gage may be rotated to any desired angle; chambers and covers are forged steel; glasses are mica protected against erosion. Available in various models for required visible glass and W.S.P.

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Engaged in the manufacture of specialty products for 53 years, the company will promote asbestos-cement pipe, plastic pipe, glass pipe wrap, and steel pipe.

Robert Hess Named President Kinney Manufacturing Company

Robert G. Hess, formerly assistant to the executive vice president of the New York Air Brake Company, has been elected president and a director of Kinney Manufacturing Company, Boston, subsidiary of the New York Air Brake Company since 1949. Hess joined the parent company in 1941 when it was still Hydraulic Controls Inc. of Chicago. When that company was incorporated into New York Air Brake as the hydraulic division, Hess became general industrial engineer of the Air Brake Company. He graduated from Lehigh University with a B.S. degree in mechanical engineering and also holds a professional degree.

Hess

Burleson, Insulation, Promoted By Johns-Manville Division

Miles W. Burleson, who joined the company in 1936 as assistant engineer, has been named assistant manager for the Insulation Department of Johns-Manville Industrial Products Division. From his original capacity Burleson was subsequently promoted to district en-

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Precision-Built for faster, smoother

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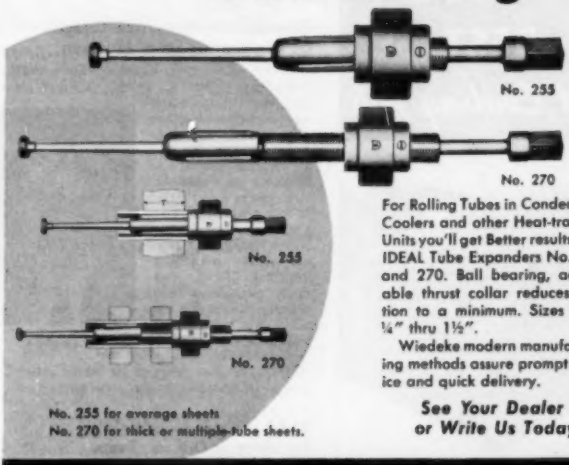

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For Rolling Tubes in Condensers, Coolers and other Heat-transfer Units you'll get Better results with IDEAL Tube Expanders No. 255 and 270. Ball bearing, adjustable thrust collar reduces friction to a minimum. Sizes from ¼" thru 1½".

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The AQUA-THERM scrubbing tower shown here was guaranteed to remove more than 99% of the H_2SO_4 mist in plant exhaust gases. Actual performance test by the customer revealed better than 99.9% removal.

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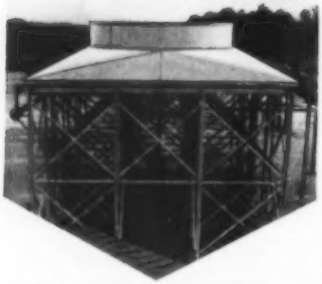

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Koppers Aeromaster Fans are available for any sizable industrial cooling requirement, from diesel locomotives to air-conditioning systems. Standard models, 5 to 24 ft. dia., with 4, 6 or 8 blades per fan. Capacities up to 750,000 c.f.m. Every fan fully guaranteed.

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Gentlemen: Please send me detailed information on Aeromaster Fans for

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gineer, Chicago district assistant staff manager for Insulation, and since 1950, staff manager to the Insulation Department in the New York office. A native of Tennessee, with a B.S. degree in mechanical engineering from the University of Tennessee, he now lives in Westfield, N. J.

Cunningham Appointed Director Of Engineering Sales At Koven

L. O. Koven & Brother, Inc., manufacturers of tanks, mixers, boilers, special process and storage equipment, have announced the appointment of Willard P. Cunningham as director of engineering sales of the Koven organization. Cunningham has been assisting the chemical, pharmaceutical, food, marine, petroleum and allied industries in solving processing, handling and storage problems for over 20 years. He has been with Koven for 26 years in various sales positions.

Cunningham

BS&B to Open New Welding Facilities at Odessa, Texas

Welded tanks for West Texas and eastern New Mexico demand will be manufactured shortly at the new Odessa, Texas, plant completed this month by Black, Sivalls & Bryson, Inc., oil field equipment manufacturers. The new building, erected at a cost of $150,000, will include a welding shop, a wood shop to be used primarily for the reshopping and repairing of wood tanks but which will also include facilities to fabricate new tanks, and a combination office-warehouse. On U.S. Highway 80, the plant will be serviced by a spur off the main east-west line of the Texas and Pacific Railroad.

Reliance Electric Moves Two District Sales Offices

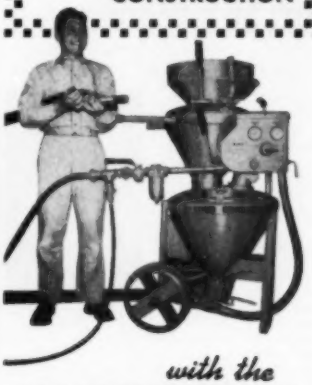
District sales offices of the Reliance Electric & Engineering Company in both Detroit, Mich., and Cleveland, have been moved to larger quarters. The Detroit office is now located at 12326 Hamilton Avenue and includes warehousing space for stocking a complete line of Reliance a-c. motors of the open and totally-enclosed types. The company subsequently plans to stock its packaged V-S adjustable-speed drives and renewal motor parts at this new Detroit location.

The Cleveland office is now operating from 13967 Cedar Road.

P. A. Bell Appointed District Manager by Baldwin-Hill Company

The Baldwin-Hill Company, manufacturer of industrial mineral wool insulations, has announced the appointment of P. A. Bell as district manager industrial sales in the New England area. Bell will operate from the Baldwin-Hill Company's sales office in New York. Before coming to the Baldwin-Hill Company in 1948, Bell was employed by Consumers Power Company and later in the mechanical engineering department of the former Commonwealth & Southern Company.

Save on MAINTENANCE, CONSTRUCTION



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Model #1000-S requires 100 CFM at 90 p.s.i.
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Both units can be operated from either plant air or portable air compressors.

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Barchard Heads Canadian Meter Division in Western Section

Canadian Meter Company, Ltd., Hamilton, Ontario, "Maple Leaf Division" of American Meter Company, has announced that Barchard Engineering and Equipment of Edmonton, Alberta, which has represented the company in western Canada since 1949, will now be operating as the Western Division of Canadian Meter Company, Limited., F. M. Barchard has been appointed manager of the new division, which will operate in British Columbia, Alberta, Saskatchewan and Manitoba, making the full engineering, sales, service and production resources of Canadian Meter Company and its parent American Meter Company, available to customers in these provinces.

Barchard

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Dimensions: 66" x 59', .750" Shell, .750" Semi-Ellip. Heads, 30 trays on 18" spacing, weight 47,500#.

Nozzles: One 6" feed, one 3" reflux, one 8" vapors, one 8" bottom, one 10" vapor-return and two 3" relief valves.

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Braun, horizontal, removable tube bundle, seamless admiralty tubes, cast-semisteel body.

4—18" ID x 12', 4 pass tubes 250 psi, 2 pass body 200 psi
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Reboiler

Braun, kettle type, removable tube bundle, seamless admiralty tubes, steel body, 26" x 48" x 21', 2 pass tubes 300 psi, body 200 psi at 400° F.

Steam Pumps

1—National Transite, Duplex, 8 x 4 x 12
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California engineering company has responsible permanent staff positions open to graduate chemical engineers with broad experience on design of condensers, stills, absorption towers and related petroleum refinery and chemical plant equipment.

Write giving full details, references, salary requirements. Your reply will be held confidential.

Our organization knows of this ad. Box 117-R, c/o Petroleum Refiner, P. O. Box 2608, Houston, Texas.

B&W Names Carl Superintendent

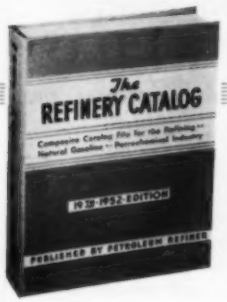
The Babcock & Wilcox Company has appointed Clayton Carl as superintendent of its West Point, Miss., works but will maintain A. P. Cramp, company plant engineer, at the site to complete construction of the new plant. Carl has been with B&W at Barberton, Ohio, since 1918.

ADVERTISERS

in the May, 1952 issue of

Petroleum Refiner

* The asterisk preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1952 Refinery Catalog.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First packaged TCC Unit features 20 BJ PUMPS...

The world's first packaged TCC unit, recently completed at Artesia, New Mexico, is a boon to the refiner of 12,000 barrels per stream day or less. This packaged plant—including feed preparation, catalytic cracking section, fractionation, gas plant and catalytic polymerization—increases gasoline yield and improves anti-knock rating at a cost factor which compares with much larger units.

In this unique installation Byron Jackson pumps of various types and sizes are used. In fact, of the 23 centrifugals installed, 20 are BJ pumps!

Whether you are concerned with pumps for a complete new refinery or a single replacement pump in an established operation, it pays to work with BJ. BJ's specialized knowledge and extensive line of refinery pumps assure you the *right* answer to your need.

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Since 1872
P. O. Box 2017, Terminal Annex, Los Angeles 54, California
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FILE FACTS:

- Designed and built by the Southwestern Engineering Co., working with Socony Vacuum Oil Co., inventors and developers of the TCC process.
- Built for the New Mexico Asphalt and Refining Co., Artesia, New Mexico.
- Fresh feed capacity—6,000 bbl. per stream day of gas oil, operating at approximately 55 per cent conversion level.

No. of Units	Type of Pump	Capacity	HP	Application and Product Handled
2	2x3x11 H Fig. 1050	215 gpm	50	Charge Pump—Handles crude oil
1	3x4x8 H 3M Process	310 gpm	20	Quench Oil Pump—Handles 650°F cycle oil
5	2x3x11 L Fig. 1050	100 gpm	30	Fractionator Reflux and Absorber Charge and Stabilizer Reflux Pumps with Type "U" Mechanical Seals
1	2x3x12½ H 3M Process	110 gpm	40	Flasher Bottom Pump—Handles 735°F Residuum
1	3x4x8 L 3M Process	180 gpm	10	Re-boiler Oil Pump—Handles gas oil
2	1½x2x8 H 3M Process	45 gpm	5	Catalytic Poly Stabilizer Reflux Pump—Handles Butanes (Pumps have Type "U" Mechanical Seals)
1	1½ YLM Bilton	30 gpm	5	Poly Reactor Wash Pump—Handles water
2	24 KXH Vertical Circulating	6000 gpm	250 and Turbine	Cooling Tower Pumps—Handles Cooling Tower Water for entire plant (Turbine drives through Philadelphia Right-Angle Gear)
2	1½ TLM Fig. 1025	105 gpm	2	Top and bottom Absorber Intercooler Pumps—Handles light hydrocarbons (With BJ Type "U" Mechanical Seal)
1	2x3x12½ H 3M Process	64 gpm	30	Recycle Pumps—Handles recycle oil
1	3x4x8 H 3M Process Pump			These pumps are used as common spares for the above services.
1	2x3x12½ H 3M Process Pump			

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Here's the Only 300 Lb. Steel Valve Which Gives You

All These Features

Compare it — feature by feature — with any other cast steel valve you can buy. Not only is it outstanding for metal quality, in the famous Lunkenheimer tradition, but it includes *all* these advanced design features:

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4. Flexible tee-head stem connection that permits the disc to adjust to its seat without binding.
5. Trim combinations for specific applications to assure the **right** valve for the job.
6. Modern end-seated seat rings that seal perfectly against the body to guard against corrosion and leakage.

WRITE FOR "Lunkenheimer Cast Steels," a useful booklet which explains valve metals, helps you match the valve to its job. The Lunkenheimer Co., Box 360G, Cincinnati 14, Ohio.

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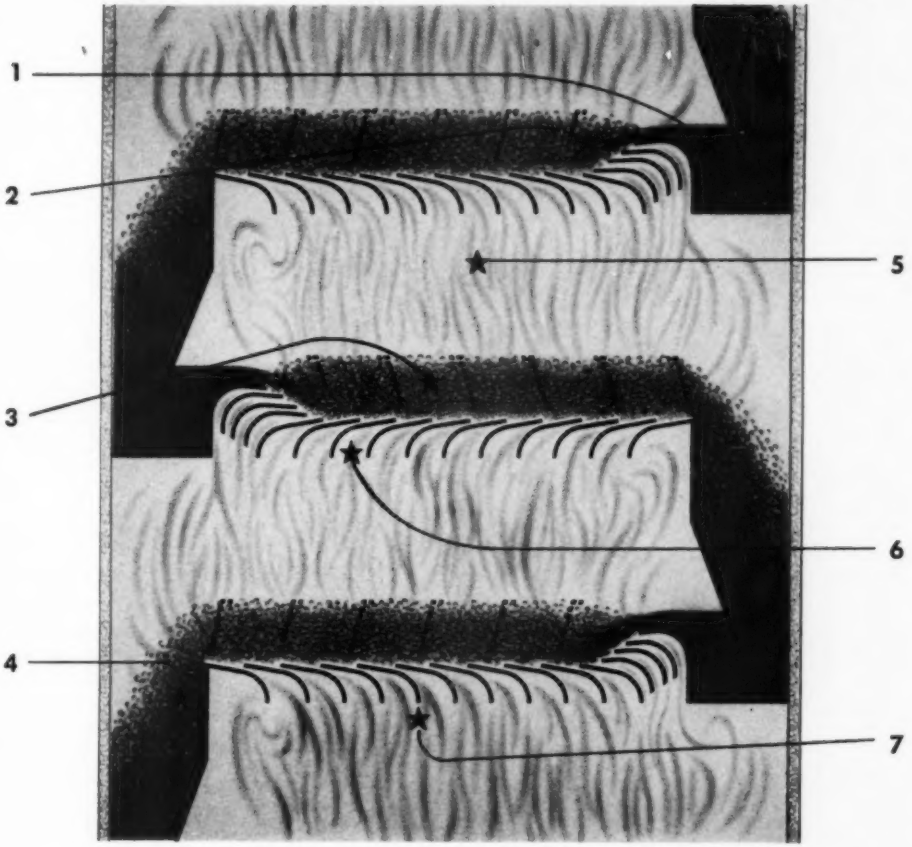

1. Conventional settling time is used to obtain dense liquid phase entering Kaskade. Bubble trays need more vertical height of dense phase in downcomer due to their higher pressure drop.

2. Dense phase is mixed or "fluffed up" while falling from inlet weir by gas rising from inductors. No liquid runback on Kaskades as found on first rows of bubble caps.

3. Mixed phase of vapor-liquid maintains uniform density while being forced through perforated baffles. Bubble caps interfere with liquid flow across the tray.

4. Frothy mass entering downcomer is more uniformly mixed than with bubble trays. Bypassed liquid on bubble trays receives contacting only in downcomer.

5. Uniform ebullition over entire area gives uniform vertical velocities reducing trajectory of liquid into vapor space. Vertical liquid trajectory from area between bubble caps limits capacity.

6. "Benturi" vapor passages, having pressure drop characteristics of a well-designed venturi, accumulate mixing energy with minimum loss of pressure drop. Energy lost in riser, reversal, and annular space of bubble cap is not usable.

7. Vane arrangement serves to coalesce and return small entrained droplets to tray below. Such devices necessary to obtain the same results with bubble trays are too expensive.

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